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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS · **AUGUST 7, 1961**

BOOTSTRAP MINER

reaches for
its own anchor

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WHEN VIBRATION THREATENS YOUR PRODUCT... page 72
WHAT'S COMING IN CONDUCTORS TO 1000 F?...
NEW EQUATIONS FOR U-SPRINGS... page 79

UNIVERSITY MICROFILMS IN
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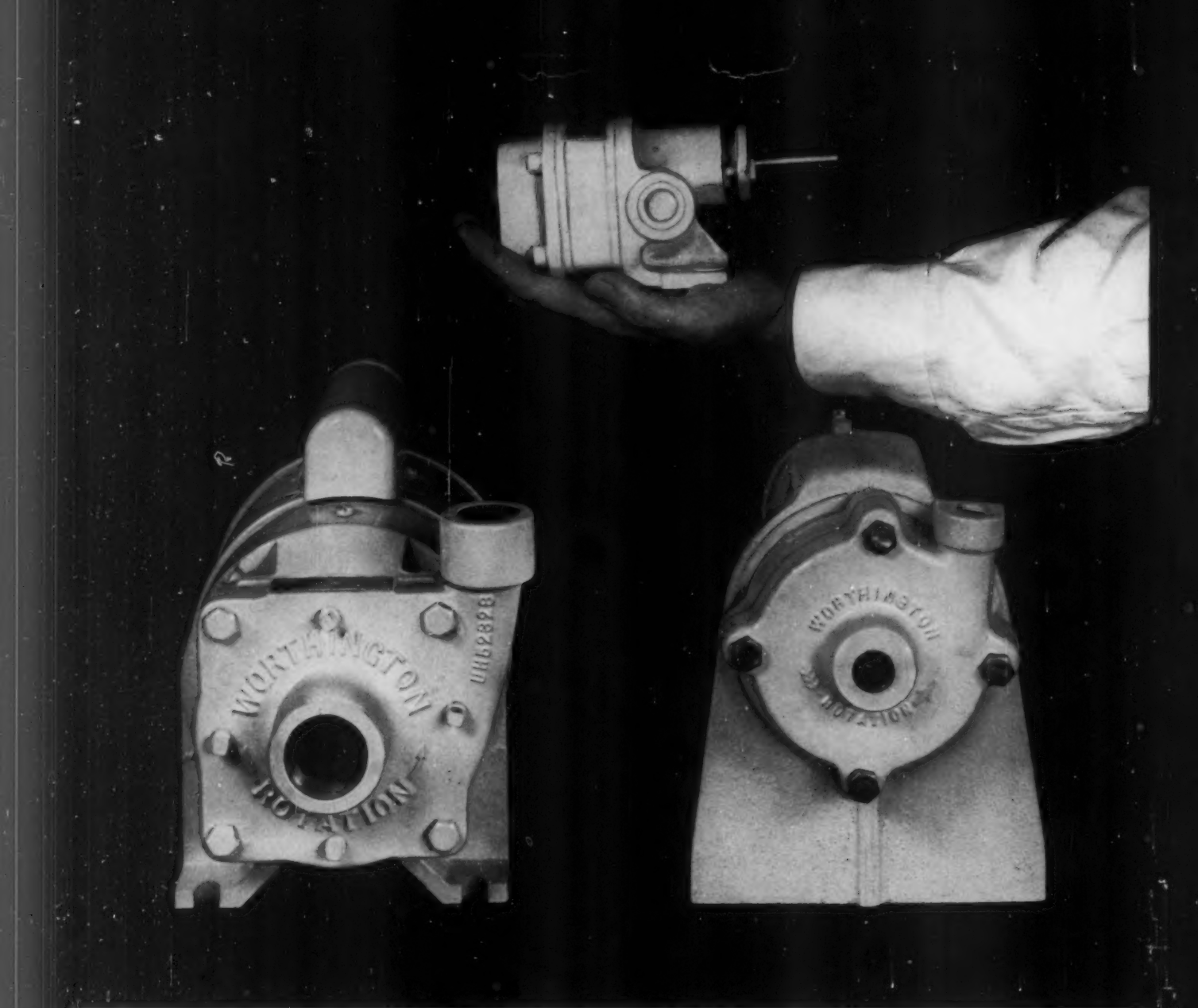

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AUGUST 7, 1961
VOLUME 32, NUMBER 32

PRODUCT ENGINEERING

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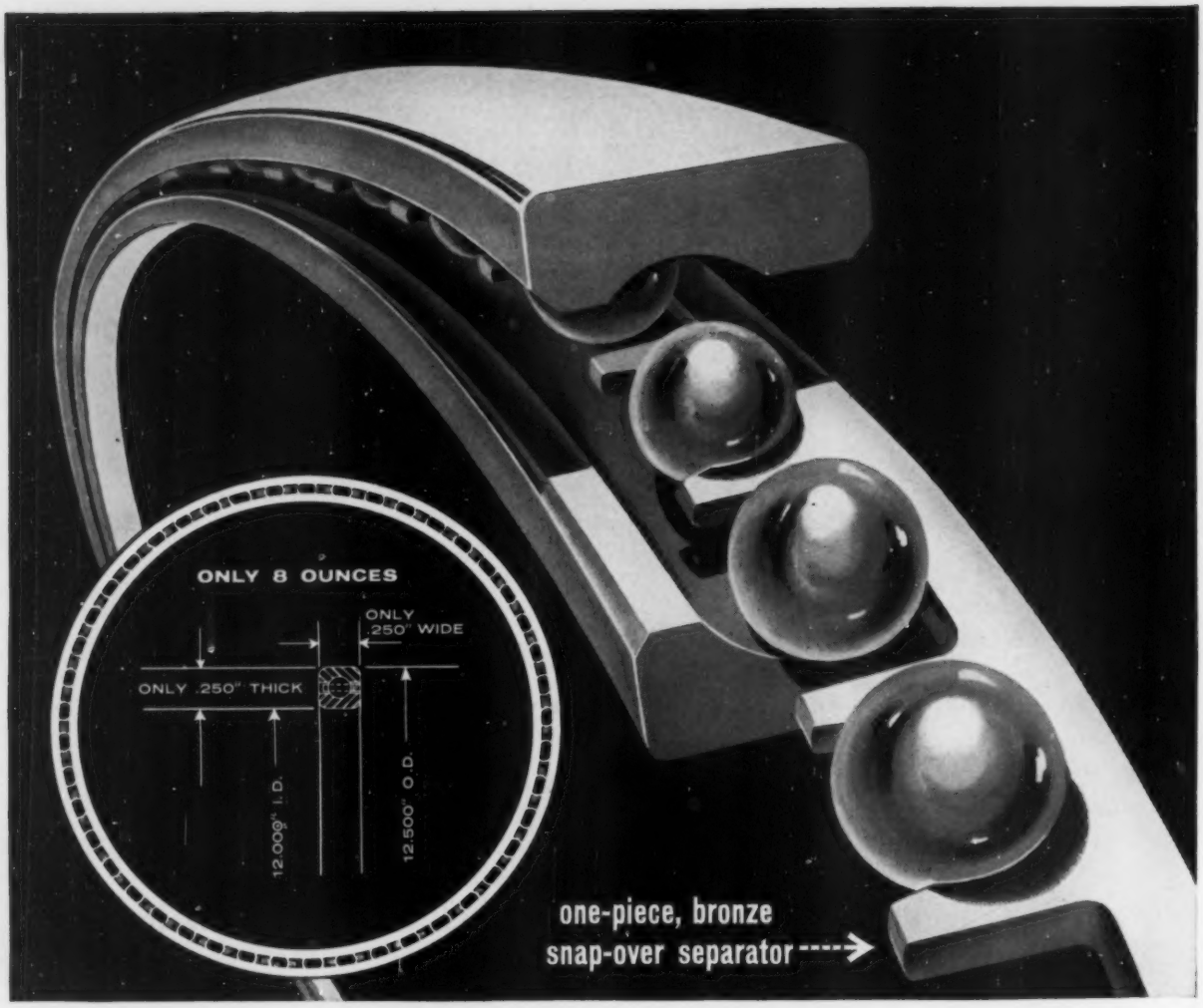
THE COVER . . .

Looking much like an Army howitzer, the Alkirk Corp pilot-pull miner dispenses with massive weights and broad gripping treads to provide drilling thrust. Instead it sends a small pilot drill forward into the vein ahead, anchors the pilot with an expanding rubber collar (or by other means) and then pulls the miner after—Mary's-little-lamb style. Direction changing is no problem as the little sketches demonstrate.

The designers have coined a phrase to describe the principle. They call it "a method of propulsion within a solid."



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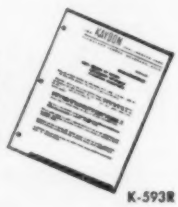

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INTERESTING TO NOTE

what price bargain

Getting the most for a dollar is an art women have been practicing for years. They call it bargain hunting. Engineers have a more technical term for it—value engineering. Or as Editor Tangerman defined it in his Special Report, "Value the Emerging Emphasis in Design" (May 15, p 79), "Value engineering is considered part of engineering and has to do with cost prevention. Value engineering is cost assurance." Computing the savings of value engineering isn't a simple matter, but it can be done—as the article on page 86 points out.

In ancient societies value hunting was often difficult—price control was common. Egyptian pharaohs or priests, whichever happened to hold primary power at the time, set exchange values of goods being traded. Price control was also practiced in Rome, Babylon and Byzantium, but enforcement wasn't easy. In 301 AD Diocletian fixed prices of food, raw materials and manufactured goods, but even the threat of death did not make his edict enforceable. By the 13th century, black marketeers wound up in jail. City fathers of London sent most of the town's coopers to prison for illegally raising the prices of barrel hoops.

During the renaissance, heads of church and state tried to check prices on basic foodstuffs and other necessities of life, but like their predecessors, they were treating symptoms rather than causes and black marketing boomed again. Today it's a little hard to tell the true value of any item—there's always someone who claims, "I can get it for you cheaper."

discovery in the classroom

Pass an electric current through a wire parallel to a compass needle and the needle will turn; stop the current and the magnetic needle swings back to its original position. The link between electricity and magnetism, which Oersted first demonstrated in 1820 by this simple experiment, underlies almost everything electrical and electronic developed since, from powerful dynamos to sensitive instruments. (See "Whats Coming in Conductors to 1000 F," p 82.)

Needles magnetized and demagnetized by "static" electric discharges, first noticed by Benjamin Franklin in 1751 and by other early experimenters, led them to suspect an electromagnetic relationship. After Volta showed, in 1799, that chemical reactions could generate electric currents, scientists stepped up their search for the elusive link between magnetism and the newly discovered "galvanism."

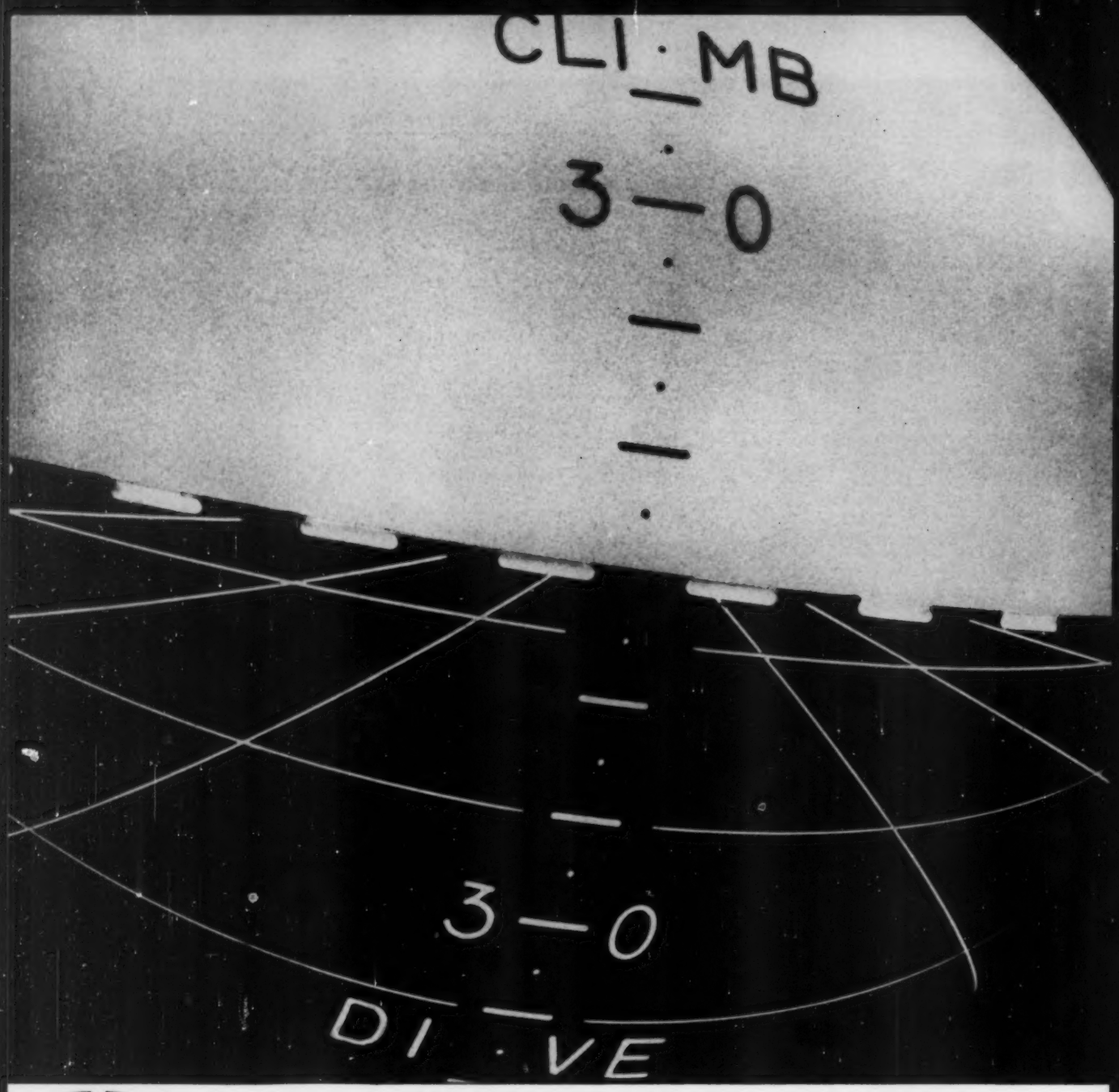
One of these predecessors nearly anticipated Oersted. In 1802 Gian Domenico Romagnosi an amateur physicist, deflected a magnetic needle with current from a voltaic pile. But he did not repeat his experiment or attempt to draw conclusions from it, and so missed the electromagnetic discovery.

Hans Christian Oersted, the man who was finally to forge the link, was stirred by Volta's discovery of the electric current and devoted his spare time to "galvanizing." As early as 1807 he announced his quest for a connection between electricity and magnetism and, in a paper published in 1813, expressed his determination "to see if electricity . . . has any action on the magnet."

Oersted notices the compass needle turn as his assistant closes the circuit of a voltaic pile.

Finally, in April, 1820, lecturing before a group of advanced students, Oersted found the "action" he and two earlier generations of scientists had sought. Placing a current-carrying wire over and *parallel* to a compass needle, he saw the needle turn sharply, as though a magnet had been moved near it. "The only instance," according to George Sarton, historian of science, "of a great discovery made during a lecture demonstration."

While the record has never been entirely clear, Oersted probably devoted the next few months to building a more powerful battery, using it to repeat his experiments. The world was quick to recognize the importance of Oersted's findings. Within several months, Ampere showed that the electric current could not only influence a magnet but actually created a magnetic field.—BAL



Lexan resin provides dimensional stability in close-tolerance parts

Maximum change allowable in the overall dimensions of this five-inch attitude indicator component is only 5 mils over a temperature range of –65° to 300°F! Moreover, the aircraft instrument part must maintain these tolerances under conditions of high humidity. To meet these severe requirements for dimensional stability, Lear, Inc. selected LEXAN polycarbonate resin.

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Government OK's development of supersonic transport

- **FAA, NASA, DOD agree that US has "unique capability for developing a supersonic transport."**
- **Major problem area is low-speed performance.**
- **Magnitude of development task and cost requires government assistance. Group proposes: FAA to give leadership and fiscal support; DOD, administrative aid and technical support; NASA, basic research and technical support.**

WASHINGTON—A commercial supersonic aircraft is now technically feasible, and could be flying in the 1970s if Congress is willing to support an R & D program to attain required safety, reliability and economical operation. This is the conclusion of the Department of Defense, National Aeronautics and Space Administration and Federal Aviation Agency, based on analyses submitted by airframe and engine manufacturers, airline operators and government agencies. The predictions are made despite a lag in development of the Mach-3 B-70 bomber.

Necessary financial aid may be forthcoming. Spurred by urgings of the three agencies, the House recently OK'd appropriation of $10 million ($12 million was requested) for development of the craft in fiscal 1962. The request now awaits Senate action.

A supersonic aircraft, manufacturers and airline operators generally agree, should cruise at Mach 3 for 3500 mi without refueling (some airlines want 5000-mi range) and carry a payload of 30,000 lb. Craft would weigh about 400,000 lb.

TECHNICAL PROBLEMS

Most difficult technical problem clusters around adaptation of the craft to low-speed performance. Most planforms submitted to the joint government committee, call for low aspect ratio, high-sweep wings to get best performance at supersonic speeds. But this configuration presents problems in low-speed maneuvers occurring during take-off, subsonic climb, holding in traffic patterns and landing.

Almost all manufacturers, therefore, recommend some sort of variable wing geometry to overcome these limitations. In a delta configuration, the wing may have a hinged tip that extends or a telescoped tip that slides out for lift. Or the delta wing may be abandoned altogether in favor of one that pivots at the fuselage.

Sonic boom is the second key problem, aircraft designers agree. They want answers to such questions as how the shock-wave system, which continuously follows in the wake of the plane, is transmitted and possibly attenuated by nonuniform atmosphere; and what levels of overpressure are tolerable to the populace beneath.

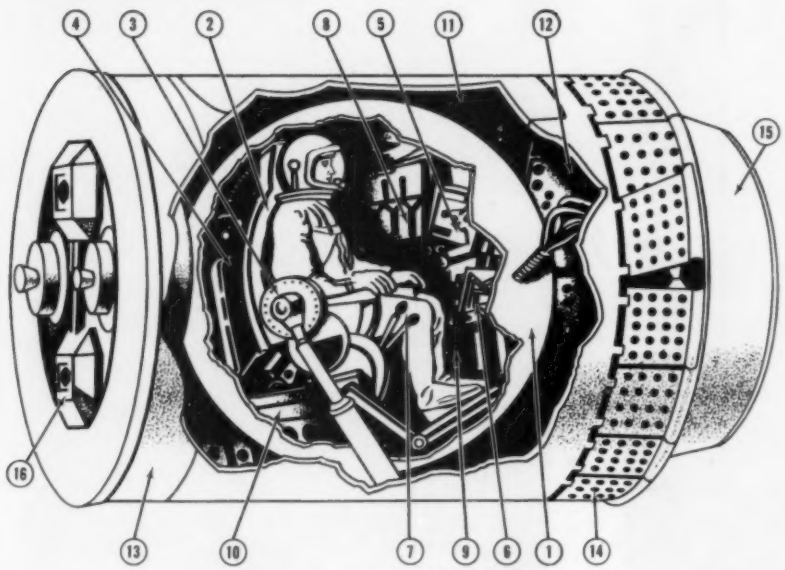
Life of 30,000 hrs—most of it at design temperature—is considered minimum for a supersonic aircraft. Because of long exposure at high temperature structures will have to be of stainless steel or titanium alloy. Aluminum alloy will be limited to temperatures below 250 F. Sandwich construction is predicted to save weight compared to conventional skin-stringer construction.

ENGINEERING RECOMMENDATIONS

The engineers recommend prompt adoption of a materials program to establish tensile, notch and elongation properties of steel and titanium after exposure to stress for 20,000 to 30,000 hr, at 500 to 600 F. Sonic fatigue at high temperature is expected to be a particular problem.

Augmented turbojets and turbofans have both been proposed for developing thrust to boost the craft to 45,000

Is this Gagarin's capsule?



A Hungarian popular science journal has published this picture of a space capsule to accompany an account of Yuri Gagarin's orbital flight last April. The account does not positively identify it as Gagarin's but its weight is said to be 4725 kg, the same as that officially announced for the capsule of the Soviet astronaut. The equipment identified in the Hungarian picture is: (1) pressurized chamber; (2) astronaut on tilting couch; (3) equipment for changing position of the pressurized chamber to ameliorate discomforts of acceleration and deceleration; (4) cabin's oxygen tank and air-regenerating equipment; (5) radar; (6) control instruments; (7) rocket deceleration control; (8) concentrated food supply; (9) water-purifying equipment; (10) communications system; (11) various electrical devices; (12) batteries and equipment for measuring external equipment; (13) outer shell of high-temperature alloy; (14) automatic areodynamic brakes; (15) parachute compartment; (16) small decelerating rockets.

ft (where sonic boom hopefully will be adequately dissipated) then accelerate it to transonic speeds. NASA presently favors the turbofan. It promises less specific fuel consumption during subsonic holding operations, and, with sufficient component development, may approach the specific fuel consumption of the turbojet at supersonic cruise speeds NASA says. Also it cruises at reduced turbine inlet temperatures—a factor favoring longer engine life.

But, at cruise speed, an augmented turbojet may be smaller, less complex and cheaper to develop and produce. A full afterburning turbojet has been ruled out because its noise during take-off is excessive and fuel consumption high. Whatever the propulsion system, the manufacturers agree it must be carefully integrated into the airframe configuration.

The plane's fuselage will tend to be long (200 to 216 ft) and narrow because of performance penalty from supersonic wave drag. A noncircular cross-section is suggested to minimize frontal area for a given volume.

TO FLY IN 1970s

Estimated development costs, submitted by the manufacturers, range from $75 million for construction of two prototype craft to $375 million for two prototypes, a preproduction craft and tooling for commercial production. Estimated unit cost for production models vary from $12.6 to $20 million per aircraft. Airframe manufacturers estimate that the R & D study phase will take from 18 months to 3 years and prototype production from 2 to 4 years. Estimates of date for final design, assuming adequate financial support, range from 1969 to 1974. Final engine design is predicted by 1967. ■

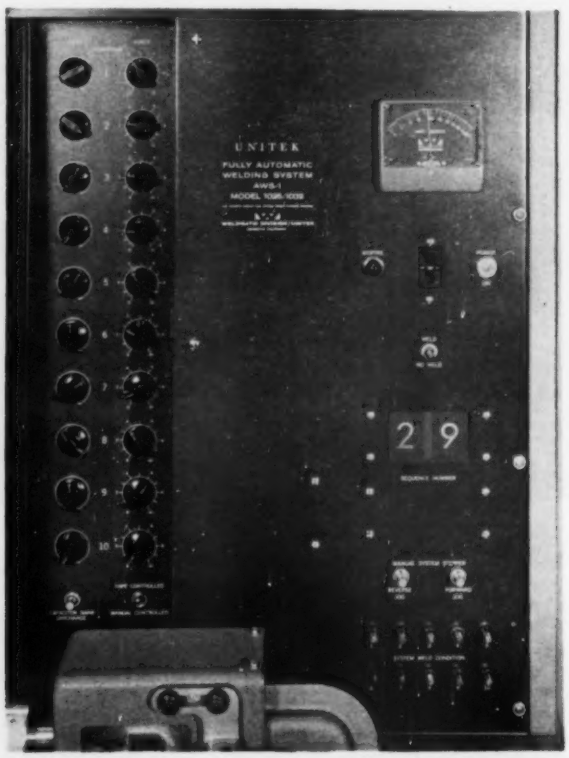
VW answers complaints by relocating engine fan

NEW YORK—Direct application of the aircooling fan on the crankshaft end is reported for the new Volkswagen 1500, to be introduced this autumn at the German Auto Fair. The current model has V-belt drive for both blower and generator, permitting engine overheating if the belt breaks.

Engine temperature is thermostatically controlled by the blower system in the standard model. Cooling air is taken past the exhaust to heat it still more, then fed to the car interior, for heating. This has been a source of complaints, especially on cold days. Consequently, in the VW-1500, part of the air will be abstracted at the blower and taken directly to the exhaust heat exchanger. ■

engineering week continued on page 10

Moveable welder controlled by tape



Close control over electrode force and welding heat is possible with a Programmed Automatic Welding System (PAWS-1), developed by the Weldmatic Div of Unitek Corp. It is designed especially for microminiature modules, vacuum tubes and other assemblies that undergo a sequence of resistance welds on different materials requiring different combinations of heat and electrode force. Electrode force is adjustable between 1 lb and 15 lb; heat energy between 0.2 to 80 watt-sec. Each tape can carry instructions for 10 different combinations. The tape program is determined by experimentally adjusting the 20 potentiometers on the control panel (right) to find the best combination for a particular job. The row of dials at left controls heat, the row at right, electrode force. During automatic operation with tape, the operator manually positions the components between the electrodes, then pushes the floor lever. An electromechanical transducer on the welding head establishes proper force between the electrodes and a capacitor furnishes heat according to tape instructions.

An example of Avisco Rayons in Industry

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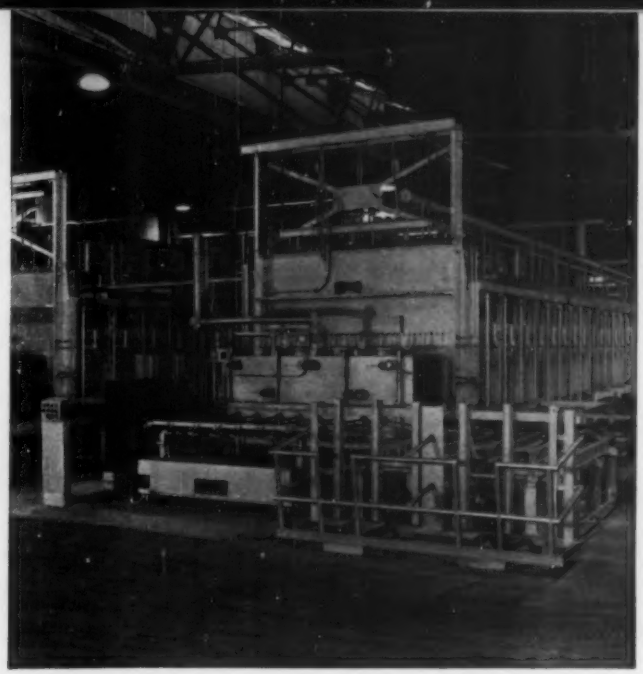

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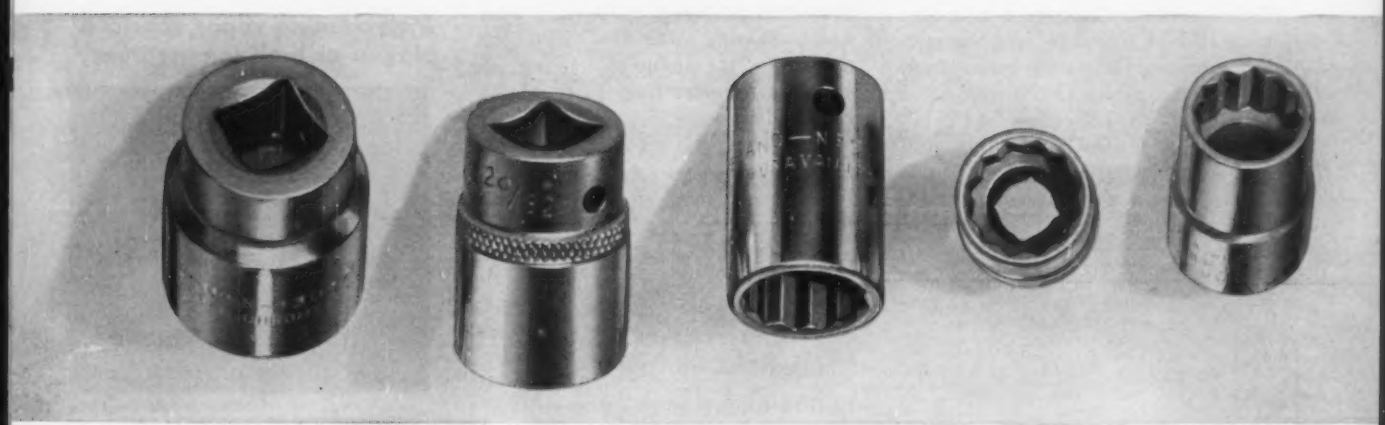

WRENCH SOCKETS, made by Herbrand Division of The Bingham-Herbrand Corporation, Fremont, Ohio, illustrate the kind of application where the superior strength, toughness, and machinability of *Republic Cold Finished Alloy Bars* help produce a better product at lower cost.

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Despite Gagarin, Soviet leaders worry over engineering, science lag

Moscow—Kremlin leaders, alarmed by persistent snags in the Soviet scientific effort, have ordered a sweeping reorganization. In the process, there will be efforts to clear deadwood out of the labs and bring in bright, young scientists. And there is renewed willingness to borrow Western technology.

More than 2000 scientists gathered here recently for the All-Union Conference of Scientific Workers. Although the usual speeches were made extolling such successes as Yuri Gagarin's orbital space flight, the participants were treated to some unusually frank talk from their leaders on what is wrong with Soviet science.

The big problems have plagued the Soviet effort for years: duplication of effort; lack of cooperation between scientists working on related problems; and, worst of all, a stubborn lag in putting scientific discoveries on the production line.

Soviet leaders appear to feel that these problems, heretofore tolerated, must now be solved because the published science budget has grown from 874 million rubles ($970 million) a decade ago to 3.8 billion ($4.2 billion) in 1961. And the technological race with the US is gathering steam.

Here are some of the shortcomings:

- Last year, the plan called for introduction of new technology in 891 projects—but only 64% were completed, and 10% were not even begun.
- In 1954, Academy of Science researchers evolved a new principle for using semiconductor instruments as nonlinear capacitors. "Yet we started working on the improvement and utilization of these instruments only after the foreign press reported their use in parameter amplifiers." Semiconductor work is still considered unsatisfactory.
- Soviet chemists were the first to synthesize stereoregular polyisoprene rubber, which has properties close to those of natural rubber. "But we are now lagging behind the US in getting production of this important material."
- Some 150 organizations are designing digital programming control systems for automation of machines and installations. But most are directing their main attention to designing computers, usually with no improvements over existing models, rather than creating new automation systems. The application of automation in industry leaves much to be desired, speakers agreed.
- Supply of scientific instruments is not keeping up with demand.
- Perhaps most interesting of all—in light of Western publicity about Soviet scientific training—is the admitted problem the Soviets are having in selecting and training young scientists and integrating them into the main stream of research work.

M. V. Keldysh, president of the USSR Academy of Science, noted that half of the 4000 persons receiving doctorates in the past 10 years were over 50 years old. He called for measures "to promote training of scientists no older than 30 to 35 for independent scientific work."

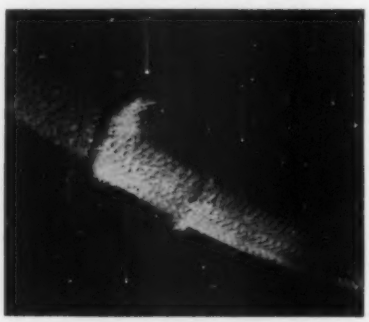
Too often, the speakers note, the higher educational establishments in Russia fail to teach students to think for themselves. Most of those completing graduate work fail to defend their theses successfully within the allotted time. Also, young scientists, who don't have the capacity for research work, are kept on for years, thus shutting out others who may be better qualified. In other cases, young grads are assigned to older scientists, who want only "blind obedience." And some established scientists choose "incapable assistants, who they are sure can never become rivals."

As disciples of central planning, the Soviets are convinced there is nothing wrong with their scientific program that more and better planning won't cure. In the past there has been too little coordination, or even exchange of information between many research institutes scattered about the country —and even less between them and industry. As Keldysh puts it: "Plans for introduction of results of research work were often severed from plans for design, and no provisions were made for experimental bases that would insure construction of pilot installations."

Several weeks ago, the Kremlin announced abolition of the State Scientific and Technical Committee, which had been responsible for introducing new technology. It was replaced with a State Committee for Coordinating Scientific Research, whose function was spelled out at the conference. Along with the Academy of Sciences, the new committee will draw up a unified plan covering three stages of research: immediate transfer of experimental designs, useful to the economy to the production line; long-range scientific investigations of technology that's potentially valuable to the economy as thermonuclear research; and, fundamental research, that seems promising, but is unpredictable.

On the manpower side, teachers will be given leaves for active research,

Molybdenum-vapor shorts a plague at high temperature



Though a boon to structural engineers, molybdenum may well cause perplexing problems to their electrical cousins, Boeing engineers have learned. Trouble arises when small amounts of the material vaporize and react with 1500-F air to become molybdenum trioxide. Normally a protective coating shields the metal, but hairline cracks or holes in the coating may admit air. At this temperature, the molybdenum trioxide is highly conductive and even a small quantity will cause short circuits when it penetrates electric wiring. Below 500 F, the vapor crystallizes, forming tiny whiskers, as shown above, which insulate the wires. The electrical system operates normally, until high temperatures are again attained. To guard against these gremlin-like attacks, Boeing is protecting wiring in the Dyna-Soar electrical systems with solid metal sheathes.

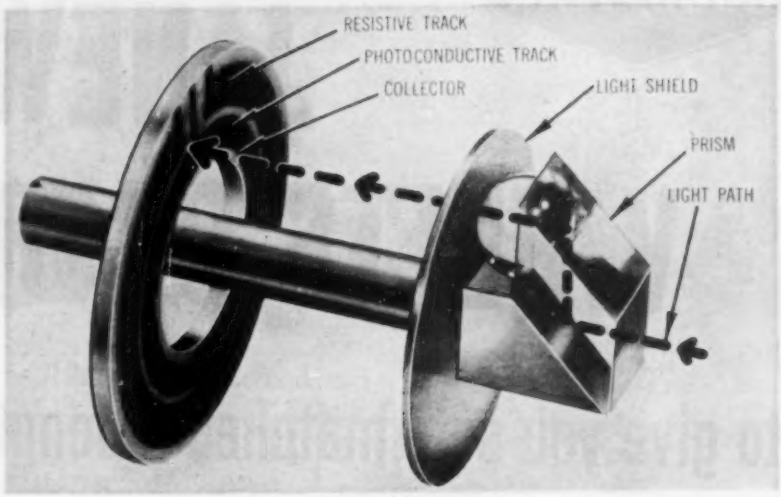
and young scientists will get time off (with pay) for graduate work. Full-time graduate students in science must first have at least two years of practical production experience. And 1000 full-time research jobs will be created for present faculty members who are working on "problems of vital economic importance."

Meanwhile, the Soviets aren't too proud to do what they have always done—making up their failings by buying or borrowing from the West. Koskgin told the meeting "We have beaten the world in solving extremely knotty and important scientific and technical problems. But we must not forget that in the leading capitalist countries science and technology are advancing rather quickly, despite all the antagonisms that are tearing the capitalist world apart."

He said purchase of Western inventions "of interest to the Soviet national economy is of great importance for the speediest technical and scientific progress, and can save much effort and time." In turn, he said Soviet patents could be sold to the West.

—Ernest Conine, Moscow Bureau

Potentiometer has light beam brush



A potentiometer, activated by a light beam instead of contact between a wiper arm and resistive element, has been developed by Duncan Electronics, Inc of Costa Mesa, Calif. In this system, light strikes a prism on the potentiometer shaft and is deflected to a track of photoconductive, semiconductor material at a point determined by the angular position of the shaft. The semiconductor material, normally passive, becomes immensely conductive when struck by light (conductivity ratios normally range from 10^6 to 10^8:1). Thus, the movable light beam defines a path of high conduction between the annular conductor and the resistive elements. One of the chief advantags of such a system is its friction-less pick-off, which is said to result in virtually unlimited life.

New car sizes complicate auto jargon

DETROIT—With introduction of at least three "in-between" size cars next month, car nomenclature will become more complicated, perhaps requiring an expanded set of terms to classify all sizes across the 1962 auto spectrum.

New Models, between compact and standard size, will be marketed by Chevrolet, Ford and Mercury. The new Ford wheelbase will be 115.5 in, Mercury's 116.5 in. Chevrolet will produce a 110-in.-wheelbase super compact probably called the "Corsair" or "Chevrolet Nova."

Industry observers, settling on an adequate descriptive system to clear away misunderstandings, are classifying the new models according to wheelbase:

Small—100 in. wheelbase or less

Compact—100 to 110 in. wheelbase

Stanpact (between compact and standard) 110 to 116 in. wheelbase

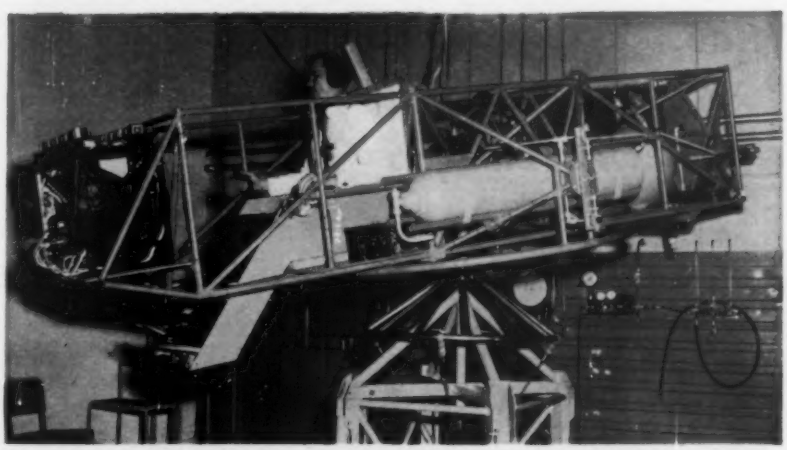
Standard—116 to 126 in. wheelbase

Luxury—126 in. wheelbase and over

Most reports from here this year will classify new cars according to this concept, or a very similar method.

—Wes Perry, Detroit Bureau

1350-lb test platform floats on air bearing



The problems of designing controls for space vehicles are being simplified by this automatic controls evaluation simulator (ACES). A 12-ft-long, 30-by-36-in., aluminum platform, it rests on a 4½-in. steel ball, floating on a column of nitrogen pressurized to 120 psi. The structure is said to move so freely that the weight of a coin will cause a reaction. It can rotate 35° up or down (pitch) and from side to side (roll), or twirl freely about its axis (yaw) except when connected to a remote control console by wiring. Control is provided by 8 reaction jets: 2 for pitch, 2 for yaw and 4 for roll. The jets are supplied by nitrogen gas carried on the platform in tanks pressurized to 3000 psi. Now operating at Chance Vought's Astronautics Div, the test platform is used in developing reaction jet and other control systems and measuring the effects of such design features as an antenna or solar-cell array on a space vehicle.

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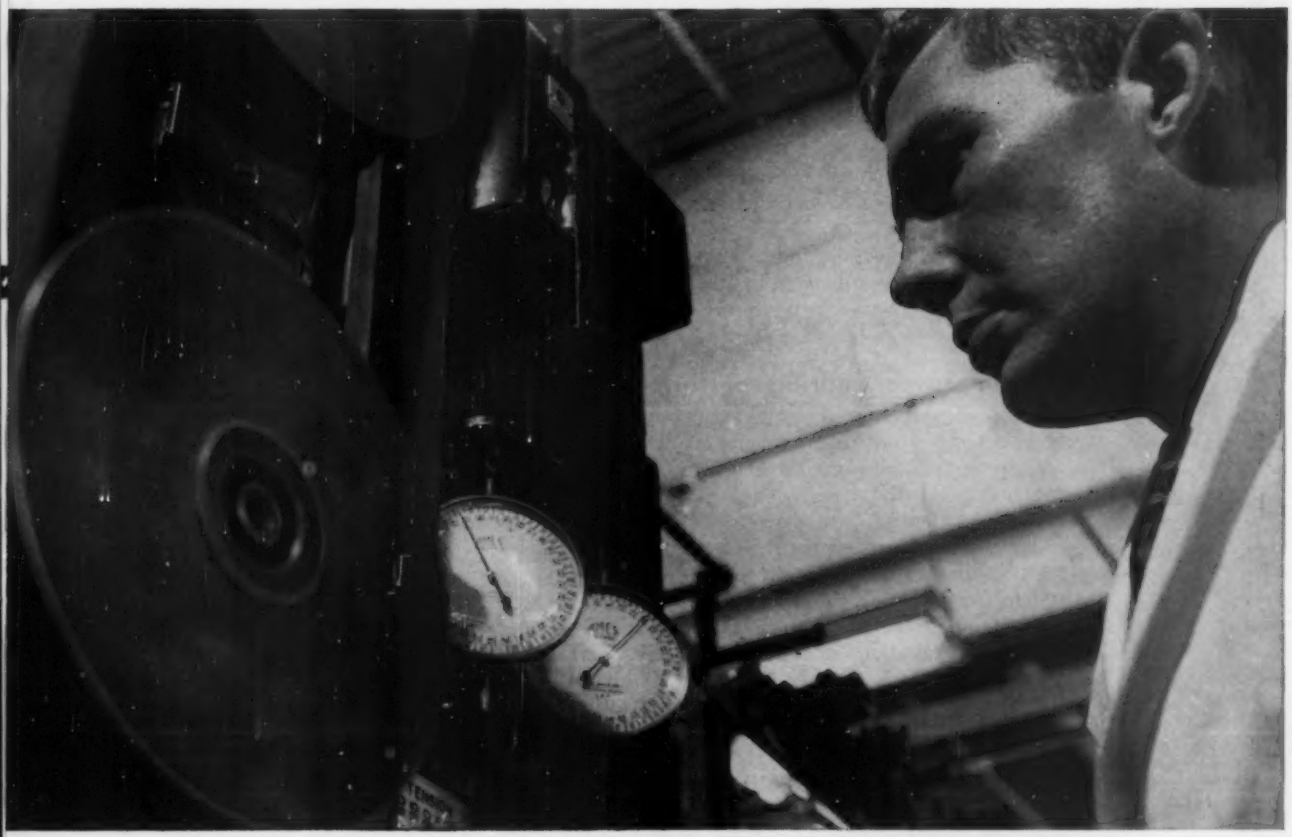

LENGTH-CODING GREEN SEAL V-BELTS TO 1/32"—NOT JUST 1/10", LIKE MOST BELTS—takes this ultra-precision machine. Only Goodyear has this type equipment, which is set by means of fine tolerance steel templates to insure accuracy. Machine readings are in the actual code numbers used to eliminate errors.

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DEVELOPMENTS TO WATCH

Dynamometer gets new features for improved performance

Automatic transfer of torque ranges from one disk-and-spring system to another, to eliminate manual changing of springs, and a new hysteresis brake design to improve high speed performance, are key features of an absorption dynamometer being readied for introduction by John Chatillon & Sons, New York 38.

The hysteresis brake has a divided stator. The heavy coil section is firmly mounted and restricted from rotation. The other, lighter element, containing the magnetic poles, is attached directly to the indicating system. This, says Chatillon, reduces starting torque of the system and permits use of fewer and smaller ball bearings.

Note: Additional design information, and construction diagram, will appear in a forthcoming issue.

New high-temperature ceramic developed by Bureau of Mines

A refractory that has a melting point above 3000 F, resists oxidation at least to 1800 F, and is stable in hydrogen, water, and hydrochloric acid, is described by the Bureau of Mines' Norris Research Lab.

The new material has a good many advantages. It combines high hardness ("in the range of quartz") with low density (less than 3 gm/cc); and, because it bonds well to stainless steel wire and other materials, it may be especially useful for reinforced structural parts.

The refractory is a high-boron composition (17% boron by weight), produced by an exothermic reaction, using silica, boric oxide, magnesium powder and chromic oxide as the starting materials. Hot-pressed samples have a hardness ranging from 50 to 70 Rockwell C, a modulus of rupture in the 10,000- to 20,000-psi range, and a specific resistance on the order of 60×10^{a} ohm-cm (individual specimens ranged from 17 to 227×10^{a}, however). All specimens showed strong negative temperature coefficients—comparable to those of graphite. Coefficient of thermal expansion is similar to that of alumina.

On the debit side, are the relative brittleness and rather low modulus of rupture of the new material as compared to other cermets. However, it is hoped that further work on fabrication technique will improve these properties.

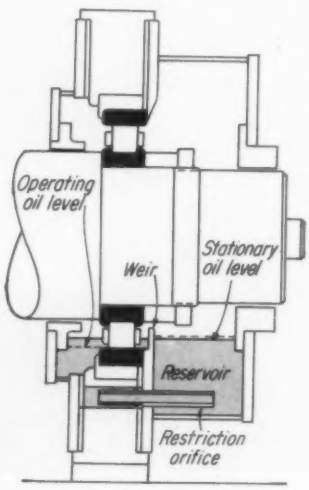
This oil-bath design improves bearing performance

Greater allowable variation in oil level, lower bearing temperature, and less aeration of the oil are among the advantages claimed for a new self-contained oil-bath system designed by A E I Motor and Control Gear Div.

The system, designed for rolling-element bearings, features an unusual reservoir-orifice-and-dam system (see diagram) which maintains a constant level of oil in the bearing compartment despite rather large variations in the stationary oil level.

According to A. F. M. Ashworth of AEI's Large Industrial Machines Engineering Dept (Manchester, England), the graph of driving torque as a function of shaft speed for the new design is remarkably similar to that of the ideal—a straight, almost horizontal line from 1000 to 4000 rpm. The driving torque for conventional oil bath lubrication rises rapidly as the shaft speed increases. Likewise, the increase in temperature as shaft speed increases is far less precipitous with the new design than in the conventional system.

AEI has patented the new design, is applying it to several types of equipment.



IN CONTROLLED SELF-LUBRICATING SYSTEM, bearing is separated from main reservoir by weir or dam, and orifice serves as bypass. As bearing rotates, weir deflects part of oil, creating difference in oil level that permits predetermined rate of oil flow into bearing compartment. Since this rate exactly equals rate of discharge of oil over weir, oil level is held constant.

Manned undersea station proposed for design and development

A "space ship" under the sea is proposed by D. D. Chapman of Boeing. The aim: to study the effects of pressure, heat-loss, and corrosion; to develop submerged drilling rigs for the oil industry; and to make nuclear tests and measurements.

In a report to the Institute of Environmental Scientists, Chapman admits there are acute problems in oxygen supply and decompression systems that would have to be solved. But, he believes, such a "space ship" can be designed; and the advantages of a shielded, isolated laboratory for the study of acoustics, high hydrostatic pressures, magnetic fluctuations, and many other phenomena would be well worth the effort.

Better insulation for aluminum with new conversion coats

Oxide films 5 to 20 times as thick as those formed by chromic and other acid treatments can be produced with sulfuric acid baths, Oak Ridge National Laboratory reports. But there are still problems in its application:

C. D. Susano of Oak Ridge notes that some military specifications bar sulfuric acid electrolytes for "assembled parts subject to stress and containing joints or recesses in which the anodizing solution may be retained." Too, rather close control is required to maintain the desired film properties. The sulfuric process is, therefore, less foolproof than the chromic acid process. Dimensional change is also likely to be greater. A 0.2-mil oxide film will cause a dimensional increase on the order of 0.13 mils. Nevertheless, after a survey of half a dozen possible systems (oxalic, sulfamic, phosphoric and boric acids in addition to chromic and sulfuric), Susano recommends the sulfuric system as "the most practical procedure for producing oxide coatings of specified thickness with good insulating properties."

(Note: For more on anodized aluminum—specifically in electrical conductors for elevated temperature use, see "What's coming in conductors to 1000 F", p 82.

New approach to motor design

Much simpler dc motors can be designed, G. A. Oberbeck of MIT told a recent AIEE meeting, by eliminating "unecessary" or "wasted" rotor teeth.

The standard $F = Bli$ formula for analyzing the forces acting on a rotor, he says, generally gives satisfactory answers. But it is misleading. It seems to show that the force is acting on the current-carrying conductors. Actually, tests show it is acting on the rotor iron.

An analysis of the current in rotor conductors placed between rotor teeth shows that, no matter what magnetic flux flows through the teeth, no torque can be developed when the tooth is directly under a pole. Once a tooth is in this position, its contribution to the motor performance is nil.

Using this conclusion as a starting point, rotors can be redesigned, with coils and commutators so wound that the teeth receive magnetic flux only when they are in their useful operating position. This means the total magnetic flux required is considerably less than in conventional designs, and smaller units can be built, using less core material.

Just as in conventional motors, Oberbeck points out, many variations in design are possible. Shape and number of rotor teeth can be varied, as can number of stator poles, field excitation, and so on. The device can also be used as a dc generator.

Chemical "drawing" produces tungsten filaments

Electrolytic etching techniques are now successfully being applied to production of fine tungsten filaments, the Soviets report.

The technique seems straightforward, but there have been a number of problems in its application. Uniformity was poor owing to current fluctuations during etching as well as variations in the diameter of the original wire.

Now, substitution of dc for ac current, application of current density controls, reduction in electrolyte concentration and the physical size of the bath, and shielding of the system from the disturbing effect of air currents, have brought substantial improvements. A 15-to-20% solution of sodium hydrate is being used, in a dual-bath system, with treatment chambers about 1¼ in. dia. Details are given in a report by I. Y. Klugman in *Tsvetnye Metally*, issue #33. —ARG

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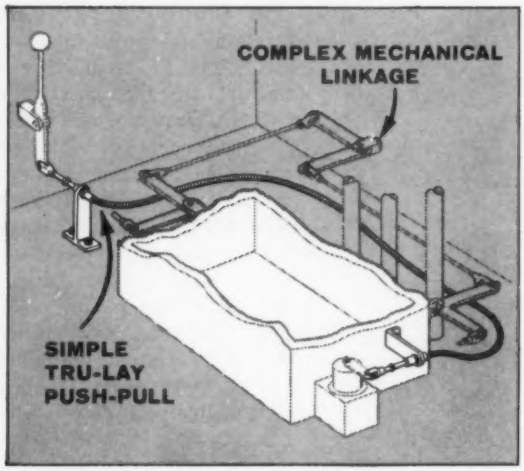

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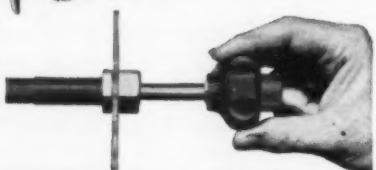

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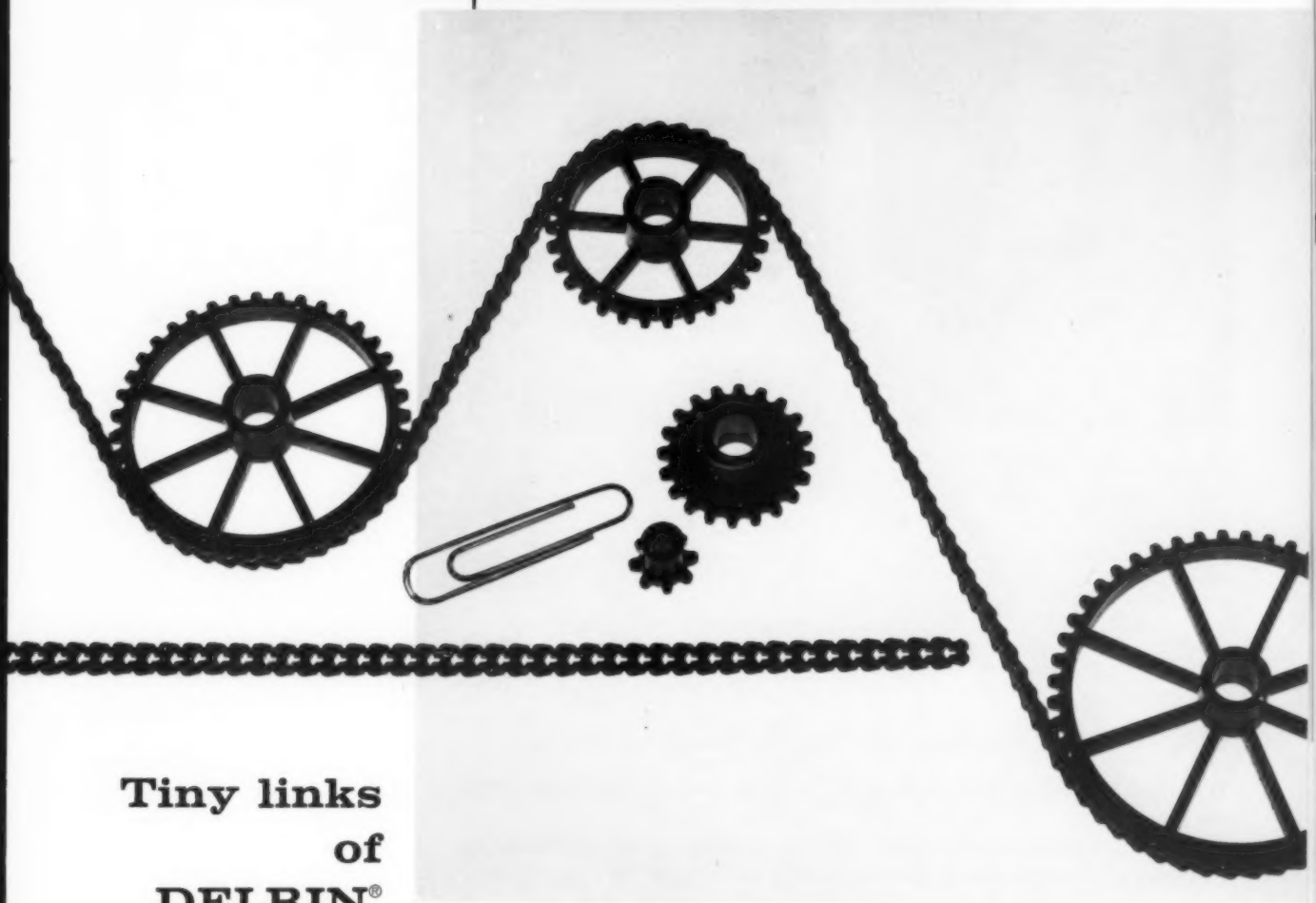

Tiny links of DELRIN® make a remarkable miniature chain

These miniature chains and sprockets are significant examples of the way Du Pont DELRIN acetal resin provides superior performance in application areas once reserved for metals. The chain of snap-fit links is made possible by the strength, stiffness and resilience of DELRIN. The need for a master link is, therefore, eliminated, making the chain adjustable in ⅛ inch increments. The chain weighs only 1 oz. per 15 ft.—one-fifth the weight of similar steel chain. It is factory-tested; momentary tension load at 7 lbs.; and running loads to 2 lbs. Manufacturer's service-life tests show a work rate transfer of 0.06 HP for 10 hours . . . 50 foot-tons of work per inch of chain. The chain is solvent-resistant, prelubricated, non-magnetic and non-conductive. These drive components were designed to fill a need in miniature mechanics and instrumentation in a wide variety of high-speed, low-inertia mechanisms.

The manufacturer, Bohannon Industries of Colorado Springs, Col., reports that of the many materials tested, only DELRIN was adaptable to the intricate technology involved in the development of these miniature drive components.

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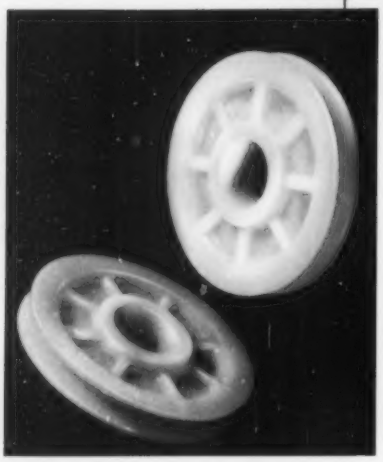
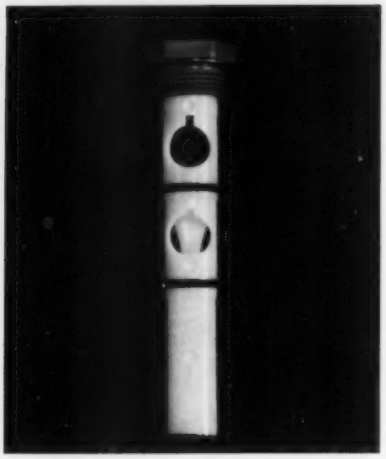


Long-wearing parking-brake cable pulleys of DELRIN® are being used by a leading car manufacturer. The full-radius groove in DELRIN provides natural mating, maximum contact area with the cable . . . eliminates the cable pinching caused by split-type steel pulleys. The new pulleys molded of DELRIN have been tested under severe long-term conditions of high load and temperatures.



Jet injector unit for shallow-well system is molded in three parts of DELRIN and joined by two "one-direction" snap-fits, giving permanent assembly. The new unit outwears bronze by a factor of 2 under sand abrasion . . . molded threads utilize high shear strength of DELRIN acetal resin. (Molded by American Molding Company, San Leandro, for Jacuzzi Bros., Inc., Richmond, California.)

Thumbwheel of this unique multi-deck rotary switch is molded of tough, abrasion-resistant Du Pont DELRIN. A single ¼ inch thumbwheel of DELRIN provides the mechanical and electrical insulating properties needed to handle a combination of rotary switches. (Molded by Par-A-Mount Tool & Mfg. Co., Inc., Chesterton, Indiana, for Chicago Dynamic Industries, Precision Products Division, Chicago, Ill.)

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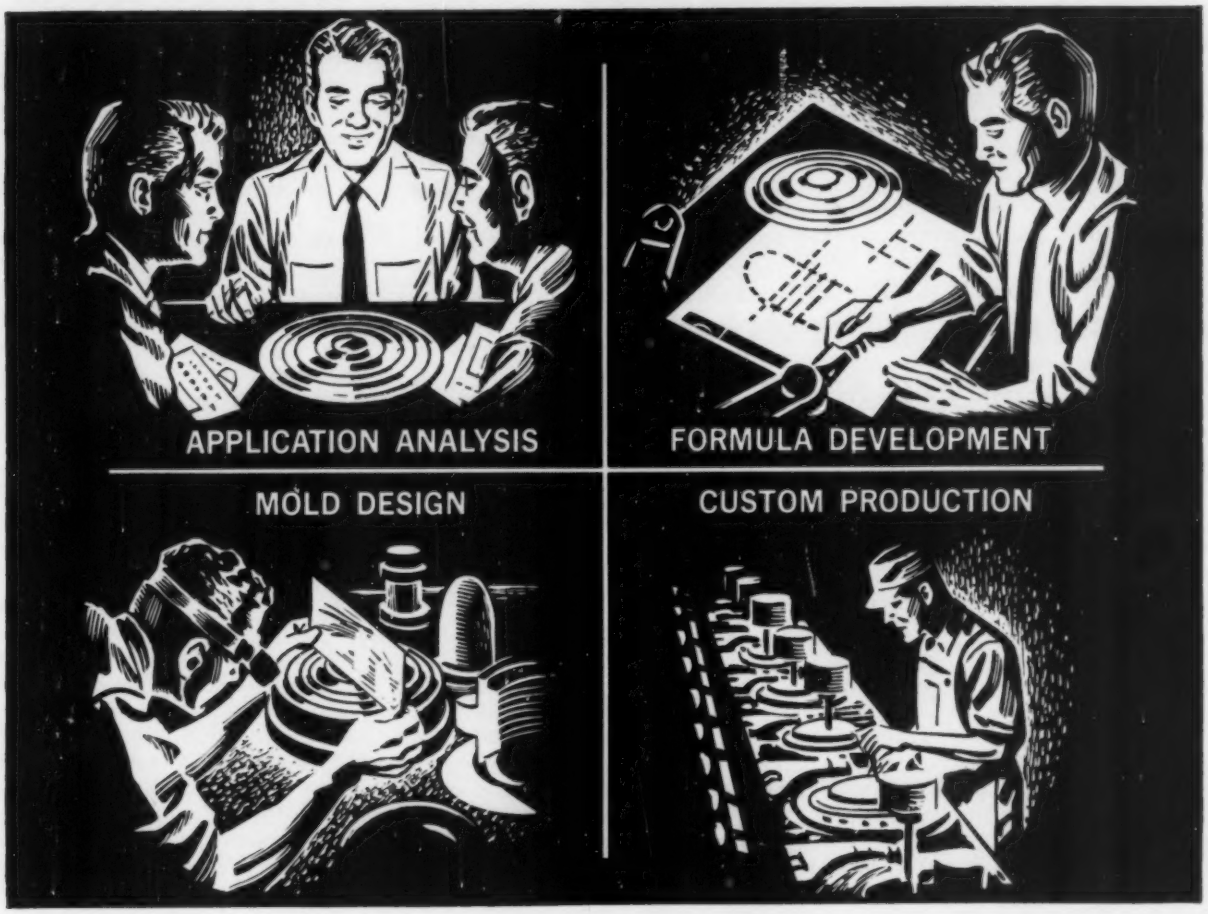

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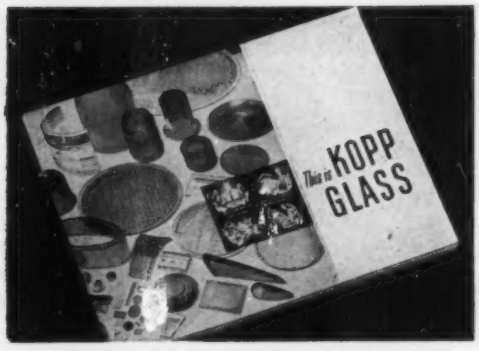

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Ceramics tested for 3800 F

When resistance to ultrahigh-temperature heat blasts is a primary consideration, three composite ceramics rate top attention: silicon carbide—silicon, chromium—28% alumina, and titanium boride—5% boron carbide.

That's NASA's recommendation after tests of more than a score of ceramics and cermets in Mach 2 jets at 3800 F.

B. W. Lewis of NASA's Langley Research Center points out that performance of ceramics in high-velocity heat jets may be quite different from results obtained in quiescent air.

When high-temperature heat blasts are involved, many ceramics that can normally be classed as "heat resistant" fail by virtue of erosion of their protective oxides. Or, they increase so much in weight and size by oxide formation that they are not satisfactory for structural parts. Among these are silicon carbide-carbon composites, and titanium carbide—nickel-molybdenum cermets.

Weight changes in chrome-molybdenum—alumina cermets, titanium boride, silicon carbide, silicon nitride, and silicon carbide-silicon nitride composites are not as serious, so these materials may prove satisfactory under some conditions. But specific testing is desirable for proposed applications.

Elastomers move out

Whether it's just a matter of service out-of-doors, or a problem in missile engineering for outer space, elastomers pose special requirements on which surprisingly little data is available, says Dr Z. T. Ossefort of Army Ordnance Elastomer Unit at Rock Island Arsenal—and RIA is out to remedy the situation.

As a first step, the laboratory exposed a series of rubber samples to direct sunlight and measured heat buildup on the surface and inside. It was not surprising to find that, after a day in the sun, the samples were hotter than they had been in the morning. But the amount of heat buildup was surprising. Even when atmospheric temperature increased only 20 degrees (from 72 to 92 F), internal temperature went up as much as 50 degrees. Furthermore, the increase was substantially the same whether the specimens were placed on a concrete or a metal base. However, buildup was slower in mineral-filled rubber than in standard block-filled material.

Now, general purpose and specialty rubbers are being exposed to simulated space environments—ranging from 100 F to 1100 F and atmospheric pressures corresponding to altitudes of 75 to 125 miles, and results of the two studies are to be compared.

In other laboratories, space studies of elastomers are also under way. GE is testing ablation properties of silicone rubber (*PE—June 19, p 8*). First tests were at 5500 F. Now, 9000 F tests are in progress; and additional studies are being made of sunlight and ozone resistance of room-temperature vulcanizing as compared to heat-cured materials.

Glass is key to stronger reinforced plastics

Glass fibers are being produced that can substantially increase the modulus of elasticity of reinforced plastics parts. But improved processing techniques will have to be developed before they reach large-scale use in rocket cases and other structural applications.

That's the gist of DMIC's most recent report on structural plastics. The newer glasses, beryllia-bearing materials, have high strength and light weight. But, says DMIC, these glasses are still expensive, and manufacturing and design experience with them is limited.

For the immediate future, DMIC recommends greater attention to processing of the Type E glasses now available commercially. "Considerable improvement in strength and constancy of properties is possible by modified and improved manufacturing processes to produce a 'missile grade' of this type of glass."

DMIC has prepared an excellent background report on glass fibers, their preparation, and properties (DMIC Memo 110), which will be available from OTS, Dept of Commerce, Washington 25, D. C., about a month from now. (Also available, as a PE reprint, 11 articles on glass fiber-reinforced plastics, "Materials and processes for reinforced plastic molded parts." Price: $2.)

Cryogenics on tape

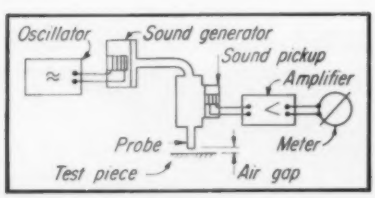
Enthalpy, entropy, internal energy, and density data for 4 gases (helium, hydrogen, neon, and nitrogen) has been compiled by engineers at the NBS Cryogenic Engineering Lab, and they've put it on magnetic tape so it can be fed directly into a computer. Temperature ranges go from normal boiling temperature to ambient. pressure ranges vary for each gas, but start at atmospheric pressure and below and extend to 100 to 200 atmospheres.

The tapes, in binary-coded decimal format, are available now from the CEL Data Center, Boulder, Colorado. Later, the information is to be published in tabular form. **—ARG**

Sound waves gage displacement

A sonic transducer that measures small displacements on much the same principle as an air gage has been designed in the Soviet Union.

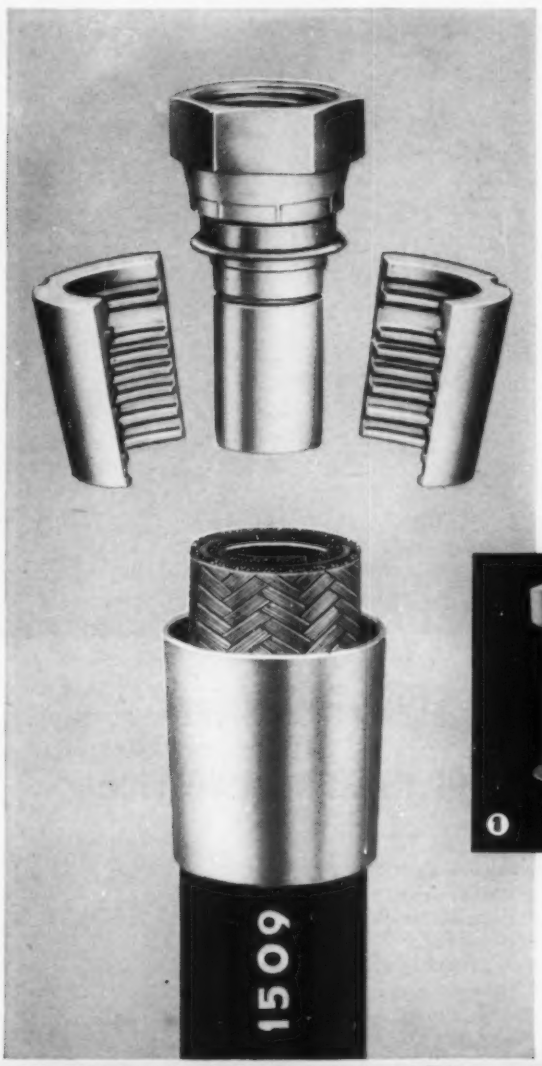
As described in *Priborostroyeniye* (#2, 1960), the instrument has an electric oscillator which powers a small speaker diaphragm. The sound waves are conducted through a chamber to a small probe facing the measured part. A microphone pickup is mounted on one side of the chamber. It senses variations in pressure and converts them to voltages which are amplified and fed to a meter.



Voltage readings are proportional to the length of the air gap.

The CIA has prepared a brief English abstract of the *Priborostroyeniye* report which, it says, is complete and detailed; but a complete translation will not be available for some time.

NEW IRON MIKE T.M.

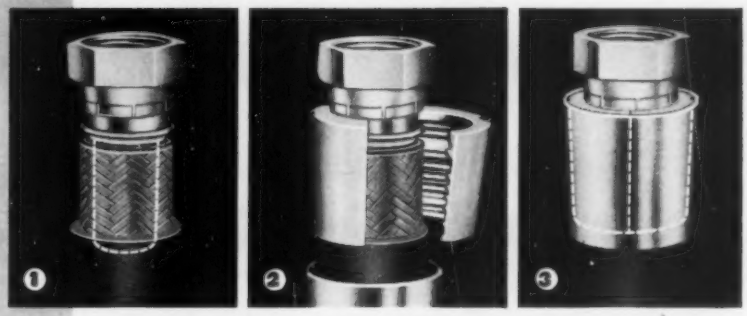


REUSABILITY PLUS LOW COST MAKE IT THE MOST IMPORTANT NEW HIGH PRESSURE HOSE FITTING IN YEARS

Aeroquip scores a major breakthrough in the cost of high pressure hose lines. IRON MIKE Fittings are completely reusable! IRON MIKE Fittings are exceptionally low cost! They give you the design, prototype, manufacturing and field service advantages provided by hose lines with standard reusable fittings . . . at the low cost of hose lines with non-reusable fittings.

Use IRON MIKE Fittings with Aeroquip Multiple Wire Braid Hose for hydraulic systems up to 2250 psi. as well as for pneumatic, fuel and lubrication lines. IRON MIKE Fittings are available with 10 standard end styles for hose sizes from ¾" to 2" I.D.

Field tested and thoroughly dependable, IRON MIKE Fittings feature quick, easy, foolproof assembly. Get complete information by returning the coupon below.



IRON MIKE Fittings consist of a steel nipple, two aluminum segments, and a tapered steel socket. Assembly of IRON MIKE Fittings and 1509 Hose is simple and sure: **1.** Rubber Cover is stripped from hose end and threadless nipple is inserted into hose. **2.** Two segments mate with nipple assembly to assure correct positioning. **3.** Tapered socket is forced over segments to form a rugged compression fitting.

PATENT APPLIED FOR

Aeroquip

AEROQUIP CORPORATION, JACKSON, MICHIGAN

Aeroquip Corporation, Jackson, Michigan PE-8

Please send me Bulletin 651 on new IRON MIKE Fittings.

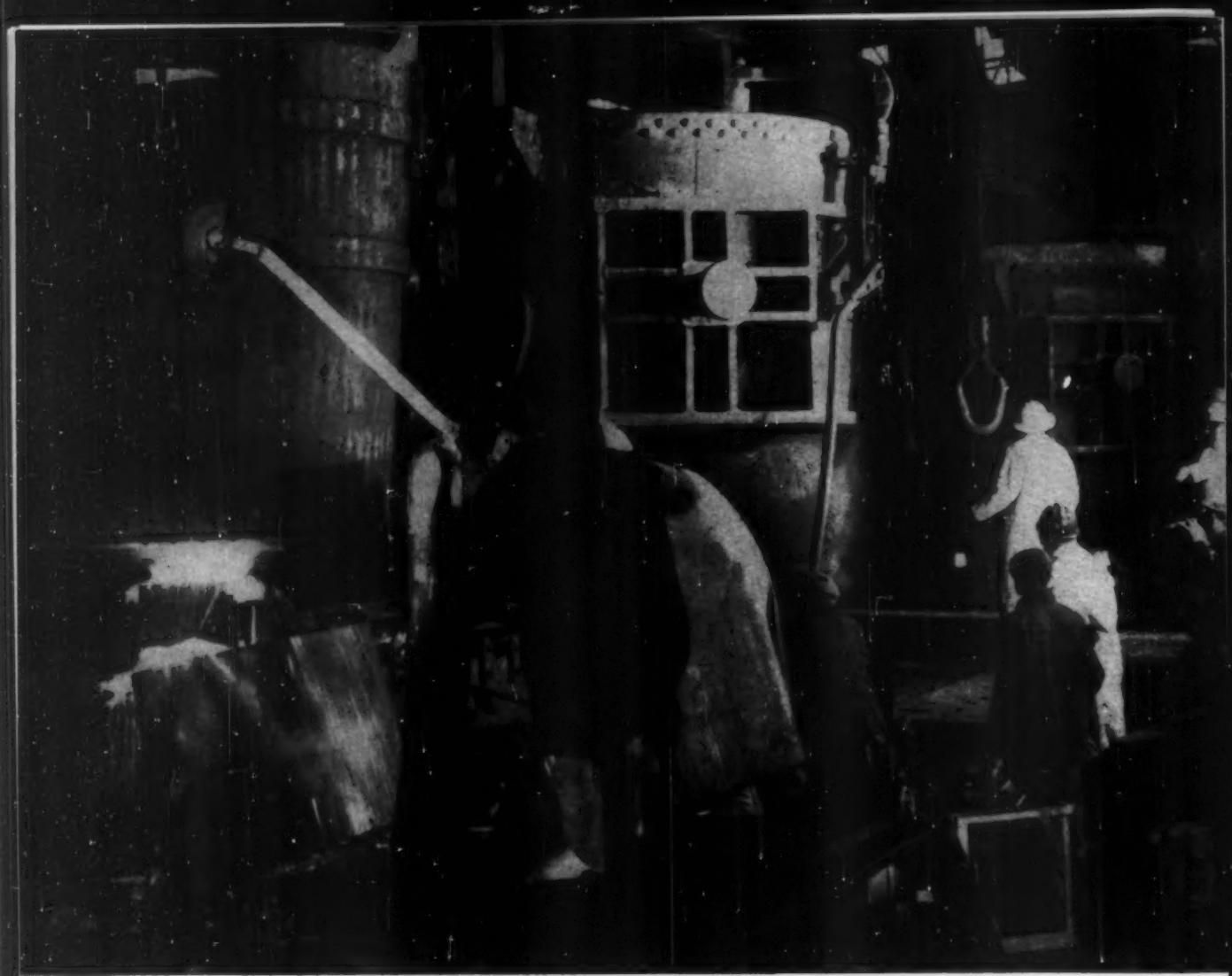
Name_____

Title_____

Company_____

Address_____

City_____ Zone_____ State_____



Specification steel making in Blaw-Knox Steel Foundries gives your product physical properties for maximum service

To insure the physical properties necessary for the service requirements of your product, Blaw-Knox maintains facilities for specification steelmaking including the regularly used mixes of carbon steels as well as special alloys such as molybdenum, chrome, nickel, and vanadium grades.

Ten acid open hearths, ranging in capacity from 10 to 70 tons, and two electric furnaces are available to produce exact quantities of many different grades of steel for many different castings at the same time. In some cases, as shown, huge castings weighing up to 300,000 pounds are poured simultaneously from three ladles.

Steelmaking to your order, in large or small amounts, is another part of Blaw-Knox Steel Casting Service that adds value to your product. And there's good reason why. Blaw-Knox, one of the world's leading manufacturers of rolling mills and industrial machines, knows how to keep an eye on the end-use conditions of a steel casting, make it for maximum service.

If you design or build products using cast steel components, ranging from 50 pounds to 300,000 pounds, Blaw-Knox would like you to have a copy of our brochure detailing Blaw-Knox Steel Castings Service. Write to the Foundry and Mill Machinery Division, 300 Sixth Avenue, Pittsburgh 22, Pennsylvania.

This intricate pipe line booster compressor housing was cast and machined at a Blaw-Knox Foundry. Test pressure 1800 p.s.i.—working pressure—1500 p.s.i. Weight—20,000 pounds.

BLAW-KNOX

Steel Castings

CIRCLE 22 ON READER SERVICE CARD

HEAT FLOW in GASKETED JOINTS

Transmission of heat through gasketed joints is undesirable in many applications. Here are suggestions for reducing it.

E. M. SMOLEY Research Physicist, Armstrong Research and Development Center

The problem of heat transmission in gasketed joints has recently been intensified by the trend toward smaller, more compact designs.

A typical example is found in some small gasoline engines where the fuel tank is located above the combustion chamber, separated only by a resilient gasket. This is illustrated in the diagram at the right. Heat enters the bottom of the flange, and the problem is to minimize the flow of this heat to the top flange.

Armstrong research engineers recently studied the mechanics of the heat transfer problem in applications of this kind. As a starting point, they calculated the thermal conductivity ("k" factor) for each class of Armstrong gasket materials. The values are listed in the box below.

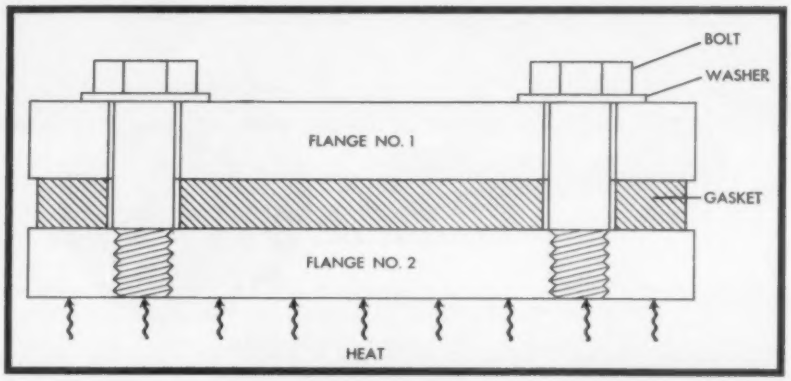
THERMAL CONDUCTIVITY VALUES FOR GASKETS

ARMSTRONG MATERIAL	Thermal conductivity k_{70} $\frac{\text{Btu-in}}{\text{hr-ft}^2\text{-F}^\circ}$
Cork compositions	0.34 to 0.49
Accopac cellulose fiber materials	0.55 to 1.17
Cork-and-rubber compositions	0.79 to 1.32
Accopac asbestos fiber materials	1.16 to 1.58
Synthetic rubber	2.22

As the table shows, all the tested gasket materials have relatively low "k" factors, ranging from 0.34 to 2.22, and thus are good insulators relative to the metal parts of a flange assembly. The "k" factor of aluminum and its alloys, for example, ranges from 612 to 1548; of carbon steel, from 313 to 360; and of stainless steel, from 104 to 165. With the "k" factors of each element known, it is possible to calculate the amount of heat transferred by conduction, using the basic heat flow equation:

$$Q = \frac{k\,A\,(t_2 - t_1)}{d}$$

In this, "Q" is a measure of heat flow per unit time; "k" is the thermal conductivity; "A" is the area of the gasket. The difference t_2 minus t_1 is the temperature difference across the thickness of the gasket; "d" is the compressed thickness of the gasket.



The total heat flow is the sum of that which passes through the gasket and the bolts, and separate calculations must be made for each.

Normally, of course, most of the conducted heat moves through the bolts, since they are the only metal-to-metal contact. If aluminum bolts are used, heat flow could be reduced by roughly one-third by substituting carbon steel. Stainless steel bolts would reduce it still more.

To further reduce transfer through the bolts, it is suggested that flat washers be die-cut from heat-resistant Armstrong materials (Accopac AN-890 or N-852) and placed between the metal washer and the flange. These should help to insulate the bolts.

Although no one recommendation can be made that will solve every heat transfer problem, the Armstrong studies indicate several general directions in which to proceed: (1) give preference to gaskets having the lowest thermal conductivity; (2) use the thickest gasket possible; (3) examine the possibility of changing to metals having a lower "k" factor in flange-bolt construction; (4) keep the gasket area as small as possible; (5) try insulating the bolt by using a washer cut from Accopac AN-890 or N-852.

If you have a specific problem related to heat transfer, we will be glad to make suggestions if you will submit details to us. Write to Armstrong Cork Company, Industrial Division, 7108 Irvin Street, Lancaster, Pennsylvania.

Armstrong GASKET MATERIALS

Choosing *exactly* the right bearing can mean a vital difference in performance, cost and product life. That's why it pays to call Torrington first.

Torrington makes *every* basic type of anti-friction bearing . . . can advise you *impartially* on the best bearing for *your* application. Needle, roller or ball . . . you won't find finer bearings than Torrington. Specify with confidence. If you have a bearing problem, call or write us today. Send for catalog information.

1. Drawn Cup Needle Bearing. Maximum radial capacity in minimum cross section. Easily positioned by press fit. **2. Drawn Cup Roller Bearing.** Ample lubricant storage for smooth starting, cool running, extra-long service life. **3. Heavy Duty Roller Bearing.** Top bearing efficiency and long life under toughest shock conditions. **4. Roller Thrust Bearing.** Precision built for outstanding performance. Large Controlled Contour rollers for maximum capacity. **5. Self-Aligning Ball Bushing.** Low cost unit for top performance in rugged applications. **6. Spherical Roller Bearing Pillow Block.** High radial and thrust capacity. Fast, easy installation. Grease or oil-bath lubrication. **7. Needle Thrust Bearing.** Unequalled capacity for size and weight. Runs directly on hardened ground surfaces, or on standard thrust races. **8. Cam Follower.** Exceptional combination of high capacity, maximum toughness, dependable performance under shock loads. **9. Spherical Roller Bearing.** Precision engineered for maximum efficiency, optimum service life. Self-aligning.

progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY Torrington, Connecticut • South Bend 21, Indiana

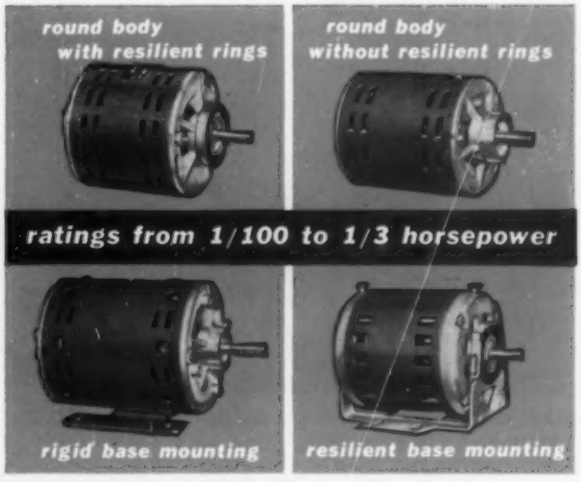
if special application FHP motors are on your mind... write for R&M's new Bulletin 445

This informative bulletin illustrates and describes in detail Robbins & Myers broad new line of Special Application FHP Motors.

You may select from four frame sizes, sixteen ratings from 1/100 through 1/3 HP, three different pole constructions, three standard mounting arrangements and four electrical types.

Simple, compact and quiet, these motors offer built-in benefits for your customers, as well as design flexibility for you, where silent operation, limited mounting space and minimum attention are factors.

Also, should your requirements be so special that a custom designed motor is indicated, our expert application engineers, using the most modern electronic computers, can promptly select the optimum design for your special requirements. Write today for your copy of R&M's new bulletin 445PRE.

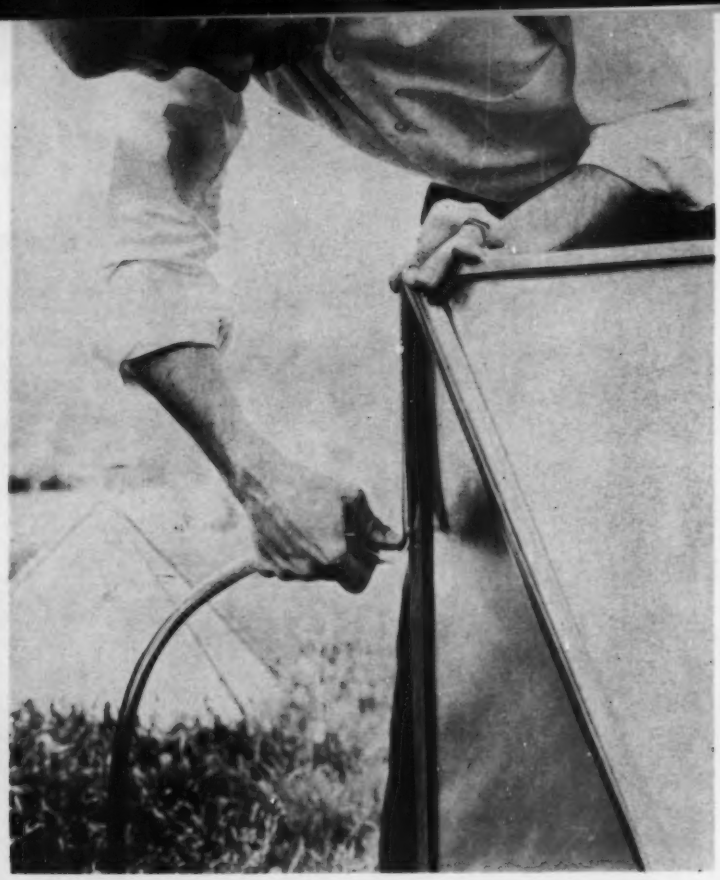

round body with resilient rings
round body without resilient rings
ratings from 1/100 to 1/3 horsepower
rigid base mounting
resilient base mounting

ROBBINS & MYERS, INC., Springfield, Ohio

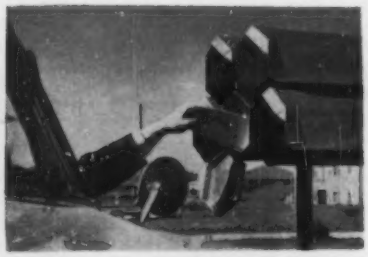
Fractional and Integral HP Electric Motors • Electric Hoists and Overhead Traveling Cranes • Moyno® Industrial Pumps
Propellair® Industrial Fans • R & M-Hunter Fans and Electric Heat • Trade-Wind Range Hoods and Ventilators
Subsidiary companies at: Memphis, Tenn., Pico Rivera, Calif., Brantford, Ontario.

CIRCLE 25 ON READER SERVICE CARD

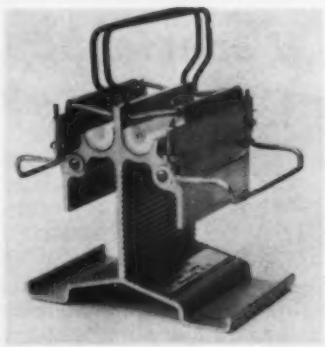
These three student designs . . .
were selected from among the six winners of Alcoa's third annual awards to new graduates of industrial design schools. All these ideas stem from senior design projects—in this case, the development of a feasible product entailing the use of aluminum. The winners represent the best solutions in the opinion of the faculties of the schools participating.



SLIT METAL or polyethylene tubing can be slid or snapped over flanges preformed on the edges of rigid sheet to form closures sturdy enough to act as a weather seal and as a light-duty, easily disassembled structural joint. Selected as the winning project by the faculty of the industrial design department of the Philadelphia Museum of Art, this "sheet-metal zipper" was conceived by Andrew A. Oakes, shown applying it here to a ice-fishing shelter which he also designed.



NESTED hexagonal mailbox is one application of honeycomb-like system of tubular shells and integral, interlocking ribs (see drawing, above) which won an award for Robert C. Taylor, industrial design div, University of Illinois.



CARRYING DEVICE for skis and ski poles is designed to be made of a single extrusion fitted with two pairs of swiveling clamps. The work of Charles H. Tipple of Syracuse University's industrial design school, it also won an Alcoa award.

Electronic cabinetry . . . used to consist of wooden boxes, brake-formed sheetmetal cases, combinations of die-cast bezels, wrappers and stamped covers, and even some sand castings, at Hewlett-Packard, Palo Alto, Calif. All this caused inventory problems, a confusing assortment of production facilities and high costs. On at least one line of cabinets, there were complaints about weight and accessibility as well. Sales records indicated that the per-sales-dollar costs of cabinetry was high—totaling $750,000 in a typical year. Nearly all these cabinets were for rack-mounted or bench-top use. Only about 1% of total sales were for slide-mounted instruments . . . yet this tiny fraction demanded the most expensive, hard-to-sell customizing.

A system approach to cabinet design was worked out based on the elements common to all electronic cabinetry: side frames (or side castings) to be die cast; front, side, rear, top and bottom panels (which simply hook on to the side frames) to be cut from 12 widths of 14-gauge aluminum sheet. If production volume warrants, coil stock will eventually replace sheet with consequent lower costs and scrap savings.

At the same time that this change of materials and production methods was being worked out, efforts to reduce the number of cabinet sizes have also been paying off. The new sizes will be limited to a range of 5¼ x 6 x 1½ in. deep to 16¾ x 22 x 12¼ in. deep.

As one of Hewlett-Packard's engineers said, after the new cabinet system was adopted, "Now we don't have a cabinet until we have an instrument" . . . his way of pointing out that with the new selection of frames and panels, cabinetry can conform more closely to the function, size and operating conditions of each instrument—and without expensive special design and manufacture. Perhaps the most dramatic evidence of the effects of the change in Hewlett-Packard's cabinet approach is that most of the 2500 sq ft previously devoted to cabinet storage has been freed, adding to the substantial material, production, shipping and labor savings.

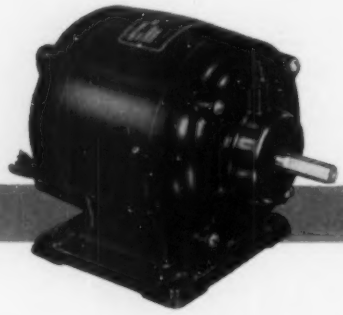
The new cabinets permit bench-top use of individual instruments, or a combination of them can be stacked by themselves or in a standard 19-in. rack. The problem of customizing the small percentage of slide-mounted units has also been solved by designing a special side panel. Now any instrument in the line is ready for slide mounting as soon as it is assembled. The basic side frames also helped in providing portability. A carrying cap clamps onto these primary structural elements and covers front panel.—JK

Bodine Motors Give You **ADE** (**A**fter **D**elivery **E**conomies)
Here's another example

"BODINE MOTORS easily meet our high standards for quality"

says Mr. Joseph Konkel
Chief Mechanical Engineer
Anelex Corporation
Boston, Massachusetts

"The reputation and reliability of our Anelex Print Station is due entirely to our insistence upon quality . . . a specification easily met by Bodine, and a requirement we'll not sacrifice at any cost. We've always used Bodine Motors. Their efficiency, among other characteristics, is outstanding. And Bodine's wide range of standard motors lets us select the proper motor for a particular operation without need for costly special modifications."



Workhorse of the electronic data processing industry is the Anelex high speed Print Station which translates computer language into usable form. It has set the industry standard for reliability and has been designed into the systems of nineteen major manufacturers of commercial and scientific computers. In this Anelex model, two small Bodine capacitor motors drive paper feed and print roll mechanisms, a type KCI gearmotor operates the ribbon drive.

BODINE
fractional BODINE horsepower
MOTORS
. . . the power behind the leading products

Bodine motors actually cost less when you figure final-costs because: (1) Closely-held tolerances and uniformity of Bodine motors minimize installation cost. (2) Reject rates are low. (3) Bodine motors almost never require field servicing. (4) High, consistent performance of Bodine motors helps your product earn customer satisfaction and repeat sales. Want more details? . . . ask for Bulletin S-2A.

Bodine Electric Co., 2510 West Bradley Place, Chicago 18, Illinois

DIMENSIONS FOR CROWN-TYPE HRH GEARS

For a gear outside diameter of unity and 90° shaft angle.

Ratio	R_a	10⅓	12¼	14⅓	17⅓	21½	25½	31⅓	38	47	58	71	87	106
Number of Pinion Teeth	n	4	4	3	3	2	2	2	1	1	1	1	1	1
Number of Gear Teeth	N	41	49	44	52	43	51	63	38	47	58	71	87	106
Offset	E	0.20000	0.20000	0.25000	0.25000	0.30000	0.30000	0.33333	0.33333	0.33333	0.33333	0.33333	0.33333	0.33333
Whole Depth	ht	0.03595	0.02859	0.03547	0.02880	0.03888	0.03200	0.02738	0.04480	0.03556	0.02827	0.02293	0.01849	0.01511
Gear Outside Diameter	D_{go}	1.00000												
Gear Crown Distance	X_c	0.08800	0.08299	0.07920	0.07800	0.06928	0.06832	0.06809	0.06027	0.06080	0.06720	0.06969	0.07004	0.07182
Gear Face Width	F	0.13003	0.13003	0.13000	0.13000	0.13008	0.13008	0.12996	0.12996	0.12996	0.12996	0.12996	0.11502	0.09440
Pinion Outside Diameter	D_{po}	0.23968	0.21621	0.22107	0.20667	0.20688	0.19296	0.18400	0.19929	0.18400	0.18400	0.17938	0.17244	0.16996
Pinion Inner Crown Distance	B_i	0.29429	0.29792	0.25413	0.25613	0.19344	0.19648	0.13849	0.13849	0.13849	0.13849	0.13849	0.17031	0.20924
Pinion Outer Crown Distance	B_o	0.48672	0.48363	0.47067	0.46707	0.44944	0.44480	0.42222	0.43289	0.42667	0.42276	0.41867	0.41422	0.41102
Minimum Pinion Mounting Distance	B_M	0.52597	0.51392	0.50013	0.49040	0.47360	0.46448	0.43644	0.45511	0.44391	0.43644	0.42951	0.42347	0.41884
Gear Spiral Angle (Deg.)	Ψ	41.45	45.00	37.69	40.83	32.03	34.55	29.42	30.56	32.49	34.00	35.16	37.39	39.71
Pinion Spiral Angle (Deg.)	Ψ_p	68.82	72.37	72.77	75.91	75.63	78.15	79.44	80.58	82.51	84.02	85.18	86.26	87.11
Pressure Degrees	Φ_1	10												
Angles	Φ_2	30												

If you're after a quieter transmission, or one that's more compact or flexible, it will pay you to look into our High Reduction Hypoids.

The set shown here, for example, gives a reduction of 300 to 1. The action is quiet, smooth and continuous. Because of the high pinion spiral angle you get overlapping tooth action with just one pinion tooth.

You can go to ratios as high as 360 to 1, yet stay within tight space limits. That's because the high-offset principle permits a more compact and flexible unit than the corresponding worm and wheel.

SIMPLIFIED DESIGN PROCEDURE—The above table shows one system for obtaining HRH gear dimensions—quickly and easily. To establish approximate details of your particular HRH pair—just select values from the table and multiply them by the gear diameter in inches. For ratios not listed in the tables, interpolation between columns gives dimensions accurate enough for layout purposes.

You get the full technical assistance, of course, of our engineering services when you design with these gears. We work with you on the practical design aspects and make prototypes. Then we furnish both machines and tooling for the desired production rate—*without royalties.*

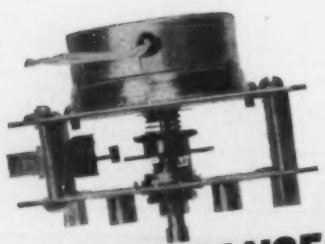
Send along a set of prints of your design and we will be glad to make recommendations on how to make the gears at the lowest possible cost.

**Trademark for Gleason High Reduction Hypoids*

GLEASON WORKS

1000 UNIVERSITY AVE., ROCHESTER, NEW YORK

SOME TIMERS DO ALL THEY ARE DESIGNED FOR—AND MORE. Others just make claims. A. W. Haydon's record speaks for itself. Behind each: 101 "pros" pooling their timing technology...sophisticated test labs to assure peak performance ...built-in reliability reflecting years of experience. ■ A. W. Haydon makes them all: timing motors, time delay relays, elapsed time indicators and the like—electronic marvels from Culver City, electromechanical wonders from Waterbury. Shown: Push-to-start interval timer for industrial use—write for bulletin. ■ If a timer's at the heart of your product, don't "buy cheap". Pennies saved here can be headaches earned later—complaints, returns, poor performance. When it's a matter of time, choose A. W. Haydon reliability.



PERFORMANCE OUTWEIGHS CLAIMS

THE AWH HAYDON COMPANY
221 NORTH ELM STREET, WATERBURY 20, CONNECTICUT

READER TO EDITOR

An Anchor Offered

To the Editor:

Should your editor like to drown himself for omitting our name from your clutch article ("Selecting Clutches For Mechanical Drives") in the June 19 issue, we have a variety of clutches which will serve as an anchor. They range in weight from a few pounds (too light in our opinion) to 4500 pounds (about right). If he's fussy, he can choose to submerge himself with any type: air, mechanical, oil-actuated or even electric. We're unbiased; we make them all.

Seriously, we're at loss to understand how you could miss an old friend who has been in the clutch game for more than forty years now. —Ed Falk, director
Advertising & Public Relations
Twin Disc Clutch Company
Racine, Wis

• Half the fun of suicide, or so my manic-depressive friends tell me, is to be discovered (or, far better, be caught in the attempt) and wept over. So a heavy clutch would be unattractive as an accessory. How we could fail to include a company as well known as Twin Disc and a decade older than we are, we don't know, but we apologize.—EJT

Updating comparison table

To the Editor:

To my April 10 article "Choosing the Right Electrical Insulation" p 41, I would like to make these additions to the comparison table on p 49:

Fire Resistance

U = not recommended
S = self extinguishing
E = non-inflamable

Enamel—Teflon E; others all U
Serving—cotton U; Dacron glass U
Liquid resins—leave blank (probably all U)
Varnishes—all U except silicone U to S
Elastomers—rubber U; silicone U to S
Papers—asbestos S to E; (depends on binder) mica paper S to E; no binder both E
Films—Teflon E; others U

The chemical terms describing DuPont's Teflon were obtained from reliable sources, and I think they are correct (except for the typographical error in which the third "o" was left out of polytetrafluoroethylene). —Art Sherburne
Louis Allis Co

That patent harangue

To the Editor:

Regarding the patent problem (July 3, p 18) Mr. Frankel signs his letters as head of his company, Mr. Corb as attorney, Mr. Johnson and I as individuals; which is indicative of our sentiments. It is assumed that all of us have read the previous Product Engineering articles on the subject. However, some of us prefer to ignore certain parameters discussed in detail. Mr. Corb makes an excellent point (June 26, p 28) that our original patent

continued, page 32

Rockwell-Standard
changes from hot-rolled A-4140 to

fatigue-proof®
STEEL BARS

elevated temperature drawing process **e.t.d.**

INCREASES PRODUCTION SUBSTANTIALLY

— doubles tool life

Increases turning production 20%

Increases drill life 50%

Eliminates heat treating

Here's an example of how a small additional investment in material enabled Rockwell-Standard to increase production and cut cost on an axle for farm equipment.

Part: Axle for a self-propelled harvester.

Steel: FATIGUE-PROOF steel bars . . . replacing HR resulphurized A-4140.

Result: Heat treating eliminated. More uniform hardness across the section (302 Brinell) including small diameters. Hand straightening eliminated. Shaft runout in turning, reduced from an average of .015" to .005" in turning. Lower cost per part.

PRODUCTION INCREASES

Turning Operations: Speed increased approximately 45%. Tool life increased from 12 to 25 pieces per tip . . . tungsten carbide tips were used.

Drilling Operations: Drill life increased approximately 50% with FATIGUE-PROOF.

Milling Keyway: Entire lot of 550 pieces were run on one cutter . . . cutter formerly required sharpening after 300 pieces.

Hobbing Operations: Production increased approximately 60% . . . from 26 pieces per hour to 44.2 pieces per hour. Hob life doubled.

FATIGUE-PROOF steel bars offer all these cost cutting advantages.

No heat treating necessary—no quench cracks, warpage or other heat treating problems. Costly operations eliminated.

Exceptional Uniformity—from surface to center, end to end, bar to bar, size to size, and lot to lot.

Faster Machining—faster than annealed alloys; 50% to 100% faster than heat treated alloys.

La Salle STEEL CO.

1430 150th Street
Hammond, Indiana

Available from your Steel Service Center

Send for FATIGUE-PROOF bulletin entitled, "A New Material." 24 Pages. Do it today!

NAME _____

TITLE _____

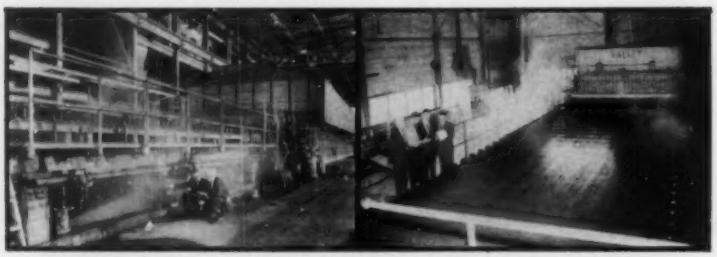
COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

The photomicrograph above, made from an etched .009" cross section of a new composite stainless alloy and phosphor bronze wire, was one of Fort Wayne Metals most closely guarded secrets since 1957; and well it might have been.

Used in Fourdrinier paper machine wire screen belts up to 200 feet long and as wide as a two lane highway, it is responsible for a major cost reduction in the multi-billion dollar paper industry.



Paper makers (many running their block-long Fourdriniers 24 hours a day) who once had four-hour shutdowns every week from wire failure—at a cost up to $1,000 an hour—now run as long as a month or more without wire trouble, even 102 days under special conditions. FWM's Drawn Brazed Strand ("DBS") provides the extra fatigue life and better chemical resistance required to bring about this saving.

"DBS" can be produced in a composite of many different types of alloys for diversified uses, including physical, thermal, chemical, magnetic, electronic and electrical applications. "DBS" may prove to be an important development in many products where high fatigue resistance, light weight, chemical inertness, controlled conductivity or combinations of these characteristics are required.

"DBS" development is typical of the ideas in precision alloy wire you can expect from FWM. We will be glad to forward "DBS" data on request.

PRECISION FINE WIRE
STAINLESS AND OTHER ALLOYS
FWM
FORT WAYNE METALS, INC.
3211 MacARTHUR DRIVE
FORT WAYNE, INDIANA

SEND FOR "FWM" IDEA FOLDERS

FORT WAYNE METALS, INC.
3211 MacARTHUR DRIVE
FORT WAYNE, INDIANA

system as signed by President Washington was extremely well conceived, it was.

Mr. Corb makes the point that all engineers receive generous salaries. Has he noticed the small and declining engineering enrolment He also makes the point that the engineers have risked nothing. Does he feel that the years of lost work in training and costs encountered are nothing? Does he feel that the majority of entrepreneurs have risked more, or have they risked other people's money? And inside information on below par stock options is so risky! —A J TRICON
Houston, Texas

Lapel pins for identification

To the Editor:

In "Interesting to Note" on p 4 of the July 10 issue the practice of some UK employes wearing company ties as emblems of alliance and seniority, is considered somewhat daft. Perhaps those who criticize have overlooked the fact that we, employed by the larger US companies, are wearing lapel pins for exactly the same purpose. Along similar lines, how do you evaluate the wearing of fraternity, society, and school class jewelry?

—NAME WITHHELD

COMING EVENTS

AUGUST

22-25 . . . . Institute of Radio Engineers, WESCON Electronic Show & Convention, The Cow Palace, San Francisco

23-25 . . . . American Institute of Electrical Engineers, Pacific General Meeting, Salt Lake City, Utah

28-Sept 1 . . . . American Society of Mechanical Engineers and American Institute of Chemical Engineers; Institute of Mechanical Engineers and Institution of Chemical Engineers (Great Britain), International Heat Transfer Conference, Univ of Colorado, Boulder

SEPTEMBER

11-14 . . . . Society of Automotive Engineers, National Farm Construction & Industrial Machinery Meeting, Milwaukee Auditorium, Milwaukee, Wisc

14-15 . . . . American Society of Mechanical Engineers, AIEE and IRE, Joint Societies Engineering Management Conference, Hotel Roosevelt, NYC

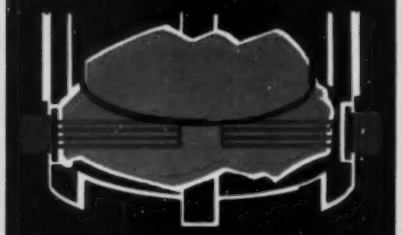
20-21 . . . . Institute of Radio Engineers, AIEE and ISA, Industrial Electronics Symposium, Bradford Hotel, Boston

For a listing of addresses of societies and associations send 25¢ to Product Engineering Reader Service Dept, 330 W 42nd St, NY 36. Ask for brochure R 32.

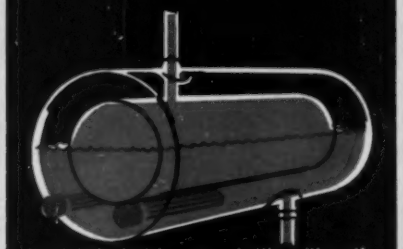
CHROMALOX Flange-Type ELECTRIC IMMERSION HEATERS

Fast, Uniform, Leak-Proof Heating for water, hard-to-contain liquids and gases

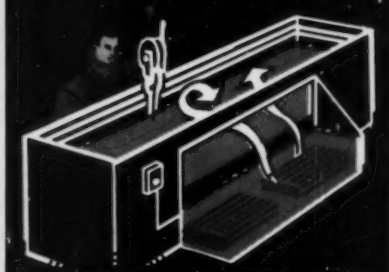
Chromalox flange type immersion heaters are made in sizes from 3 KW to 125 KW, 3" to 14", steel or stainless flanges, Steel and Incoloy sheaths.



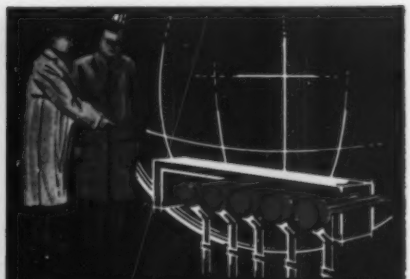
Heaters, mounted into jacketed kettles, give uniform and accurately controlled heat transfer for critical resin processing.



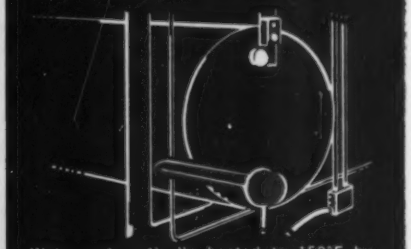
Insulated electric vapor kettle with self-contained heat transfer medium gives fast, uniform, controlled heat up to 700°F.



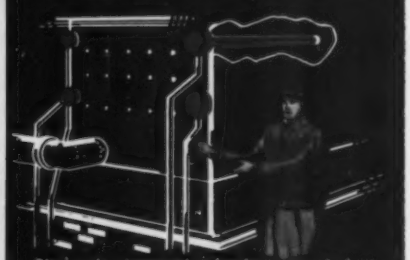
Chromalox immersion heaters vaporize trichlorethylene in side tank; vapors circulate into main tank where they efficiently degrease metal soils.



Off peak power use and the elimination of boiler, building, and smokestack more than pay off when immersion heaters mounted in storage tank, heat water to required 180°F temperatures.



Water automatically heated to 150°F by Chromalox heaters eliminates oil storage tanks, burners and maintenance; assures hot water for washrooms and other needs.



Chromalox immersion heaters operated on off peak rate "freeze-proof" water supply in plant's boilers on cold winter nights and weekend shutdowns.

Chromalox Flange-Type Electric Immersion Heaters are quick, easy and economical solutions to heating compressed air and other gases, for super-heating steam and for heating liquids of all types, including Dowtherm, Arclor, Prestone and similar heat transfer mediums. They are particularly well adapted to special high-temperature/high-pressure applications and for use in corrosive solutions. The relatively small displacement of the heaters and their high outputs, make them ideal for large volume heating with minimum work-area interference with the tank and minimum impedance to the flow of fluids. Standard heaters furnished with 150 psi flanges, special flanges withstand up to 4500 psi.

GET THE FACTS

See for yourself how Chromalox Immersion Heaters can help improve efficiency and/or decrease costs. Write for Catalog 60 and Industrial Process Bulletins.

EDWIN L. WIEGAND COMPANY
7535 THOMAS BLVD., PITTSBURGH 8, PA.
WI-21

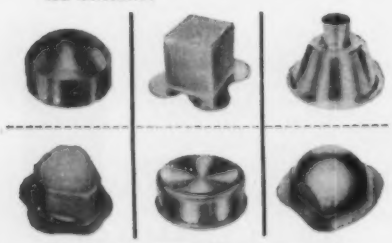
CHROMALOX ELECTRIC HEAT

PROCESS | COMFORT

KAUPP
PRECISION-FORMED
METAL
COMPONENTS

Hydroforming, Deep Drawing and Spinning

You can depend on KAUPP for complete service from design to delivery on precision-made metal parts and sub-assemblies. Ultra modern metal working facilities, plus wide experience on military and commercial requirements are available to solve your problems. Send drawings for quotations or phone for new illustrated bulletins!



Closest tolerances adhered to in all metals, including MU METAL, BRASS, INCONEL, ALUMINUM, COPPER, CARBON STEEL, STAINLESS STEEL, NICKEL, MAGNESIUM, TITANIUM, SILVER, SPECIAL ALLOYS, HAYNES STELLITE.

C. B. KAUPP & SONS

Newark Way, Maplewood, N. J.—POplar 1-4000

METAL CRAFTSMEN
SINCE 1924

WHY DON'T THEY R&D . . ?

. . . better welding methods. That is what the American Welding Society is asking for in a list of problems published in their **Welding Journal**. Once every two years they ask their membership for welding problems that need solving. Here are some samples from the most recent survey:

. . . methods and equipment for making wide seam welds by resistance welding. This would make it possible to clad one metal with another.

. . . a way of controlling the location and orientation of residual stresses that occur when two pieces are welded together. If this could be done, these undesirable stresses could be used to buck load stresses, thereby increasing the load-carrying capacity of structural members.

. . . a way to discover what effect hydrostatic pressure has on residual stresses in pressure vessels. Does it reduce or eliminate them, or will it increase stresses around nozzles and other attachments?

. . . a nonradiographic, nondestructive test for fusion welds. It must give reliable results despite variations in section thickness in the weld or near the weld area.

. . . a rod material that will eliminate spatter during welding.

. . . gussets for strengthening structural tubing. Present ones are neither as strong nor as efficient as they could be.

. . . "weld-through" paints that would not interfere with welding as much as present ones do.

. . . rolled and formed structural sections specifically designed for welding. Such easy-to-work-with shapes would cut building costs.

. . . procedures which will reduce or eliminate distortion when thin sheet is used to make welded assemblies. One help would be a means for measuring distortion during welding.

. . . a way of making resistance-welded sandwich structures. For secondary structures, welded sandwich composites should be cheaper than those made by brazing.

. . . a method for making ultrasonic spot and seam welds between dissimilar metals—molybdenum to stainless steel, for example, or molybedenum to titanium.

. . . brazed sandwich structures for service at 2000 F. Shortcomings in brazing techniques presently rule out the use of high-temperature super alloys like J-1650, R-235 and Inconel X.

Have you a problem, based on known scientific principles, which seems to have an answer somewhere within the limits of present technology? To inspire inventors along worthwhile paths, PRODUCT ENGINEERING invites you to trade your problems with readers who have a fresh viewpoint or more time to experiment. We pay $10 on acceptance.

The NEW Phillips
POZ-I-DRIV
a revolutionary new fastening development.

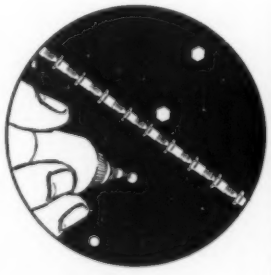
In 1933, American Screw Company gave industry the famous Phillips cross-recessed head, a fastener design that revolutionized assembly operations. And now, American presents the new POZ-I-DRIV fastener recess and driver . . . a development that offers significant reductions in assembly time and costs, increases fastening strength, improves product appearance and performance, and boosts profits.

The new POZ-I-DRIV recess is similar to the Phillips design, but provides greater driving area with reduced recess depth. This combination produces several significant advantages, including:

1. **GREATER TORQUING ABILITY** . . . making it possible to drive threaded fasteners tighter at continuous production speeds because of reduced operator fatigue.
2. **BETTER DRIVER-RECESS ENGAGEMENT** . . . practically eliminates cam-out, reduces bit wear, prolongs bit life.
3. **INCREASED DRIVING AREA** . . . with better driver stability permits shallower recess resulting in increased head strength.
4. **IMPROVED AXIAL ALIGNMENT** . . . and positive bit engagement permit 90° offset driving.
5. **COMPLETE COMPATIBILITY** . . . with present Phillips bits for field service.

AMERICAN SCREW COMPANY
Leader in Fastener Development

Since 1838, American has been making important contributions to industrial progress by the continued development of new and better threaded fasteners. Here, for example, are 3 recent developments by American Screw Company:



SCREWSTICK . . . consists of machine and fluted thread-cutting screws in "stick" form. Used with automatic-feeding driving tools, they can be applied as fast as the operator can position the assembly. Available in steel, brass, aluminum, nickel silver and stainless steel alloys.

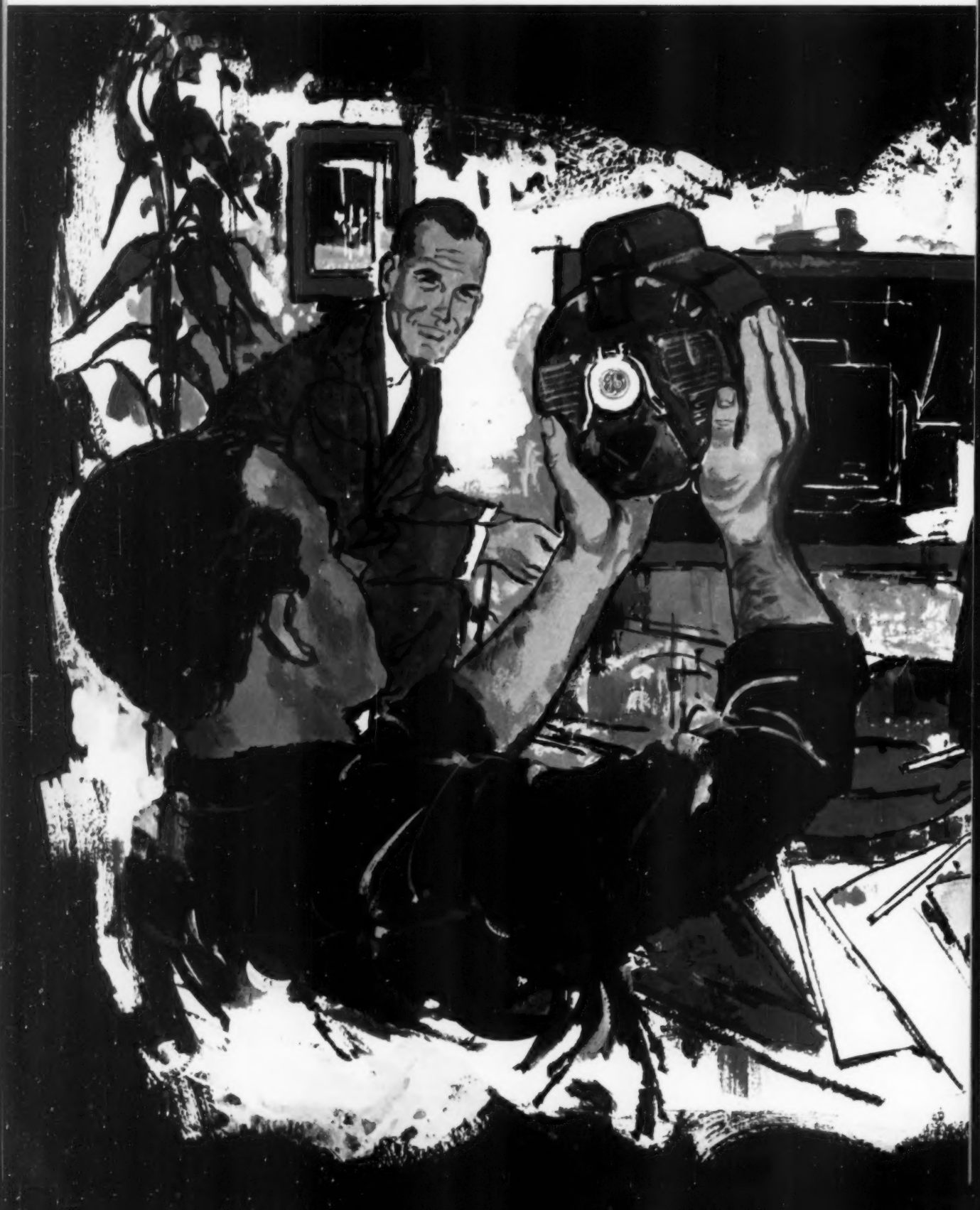
TORQ-SET . . . designed for the expanding needs of supersonic aircraft, missiles and electronic components, where maximum wrenchability and reliability are of prime importance. Recess design eliminates burring that would interfere with laminar flow.

TRI-WING . . . a tamper-proof fastener, which is virtually impossible to remove without mating tool. Designed for maximum security against tampering or pilferage. With high torquing characteristics for applications requiring extreme strength or vibration resistance.

AMERICAN SCREW COMPANY
WILLIMANTIC, CONNECTICUT
A Division of NOMA LITES, INC.

You get **MORE THAN A MOTOR** with General Electric's Form G . . . for example . . .

Expert Motor Application



Aid

Are you taking advantage of all the motor knowledge available to you? A phone call will bring a General Electric application engineer to help solve your motor application problems. He's not only an expert on G-E Form G fhp motors, but in all phases of applying them. He can bring years of motor experience and knowledge to bear for you. Why not try him?

In addition to expert application assistance, you get these **MORE THAN A MOTOR** benefits with General Electric Form G motors: *Years-ahead Design Leadership . . . Versatility Personified . . . Ease of Assembly . . . On-time Delivery . . . Fast, Local Service.*

You receive these *added values* at no extra cost. So why settle for less?

Form G fhp motors are available in NEMA 48 and 56 frames. For more information, call your G-E Sales Engineer or write to Section 721-07, General Electric Co., Schenectady 5, New York.

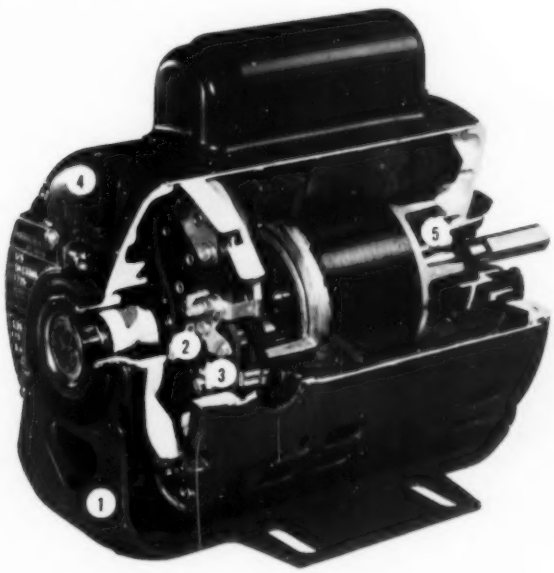
THESE FORM G MOTOR VERSATILITY FEATURES MEAN GREATER DESIGN FREEDOM FOR YOU

1. MOUNTING VERSATILITY—Both solid and resilient cradle bases permit rotation of Form G motors within base to meet design and space requirements.

2. FAST ROTATION CHANGE—Just interchange two leads; reverse rotation in seconds. This eliminates duplicate stocks for just a change in rotation.

3. FAST VOLTAGE CHANGE—Sliding plates on terminal boards allow change from 115 to 230 v operation (or vice versa) in one-fifth the time.

4. EASY, DIRECT MOUNTING—Mount Form Gs without expensive machining or brackets. Close end shield tolerances allow mounting of motor with through-bolts.

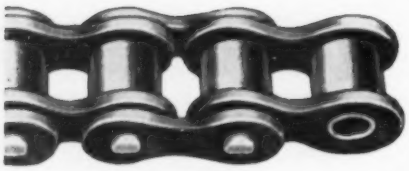


5. ALL-ANGLE OPERATION—All-angle sleeve bearing and positive oil retention system allow you to mount standard Form G motors in any position.

6. COMPLETE LINE—Over 850 basic models—and thousands of variations—mean there's a standard Form G motor for your product's *exact* requirements.

Progress Is Our Most Important Product

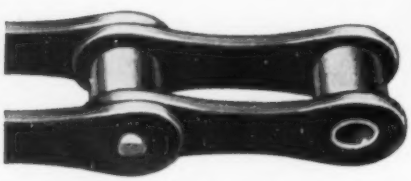
GENERAL ELECTRIC



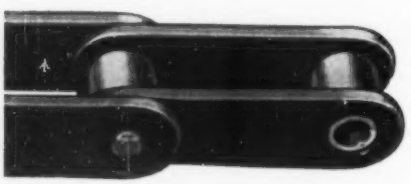
SINGLE STRAND

DOUBLE STRAND

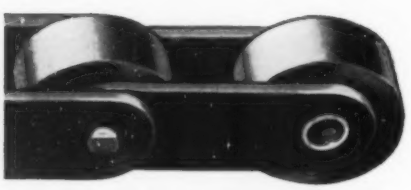
SINGLE STRAND, HEAVY SERIES



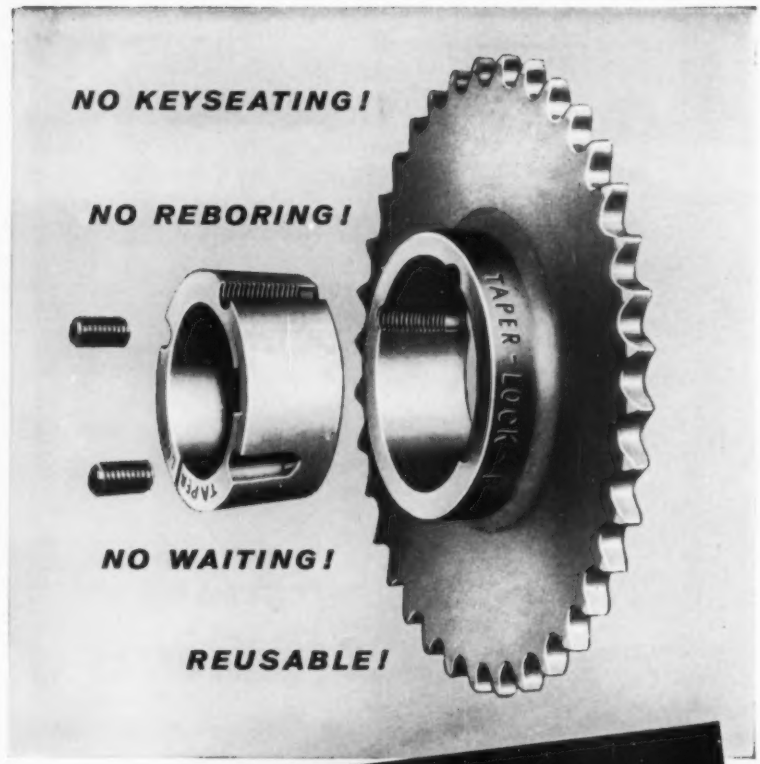
DOUBLE PITCH TRANSMISSION



DOUBLE PITCH CONVEYOR



DOUBLE PITCH CONVEYOR, LARGE ROLLERS



TAPER-LOCK SPROCKETS DODGE ROLLER CHAIN

DODGE Quality Roller Chain, teamed with Dodge Taper-Lock Sprockets, results in chain drives and chain conveyors that have the precision, efficiency and stamina necessary for the real economy of *long life*.

Moreover, Taper-Lock's reusable bushing makes a difference in overall cost. The ease of Taper-Lock mounting, the elimination of reboring, keyseating, and wasted time, add to the saving. Precision machining and true articulation lengthen the life of *both* sprocket and chain.

The Dodge line of chain, including standard attachments, is extensive. It meets a high percentage of all chain requirements.

In the Double Pitch series (both Transmission and Conveyor) the sizes which require special spacing for perfect tooth action are offered from stock in special double pitch design — to double the life of the chain and the sprocket!

Ask your local Dodge Distributor. Or write us for bulletin.

DODGE MANUFACTURING CORPORATION, 1200 Union St., Mishawaka, Ind.

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under "Dodge Transmissioneer" in the *white* pages of your telephone directory, or in the yellow pages under "Power Transmission Machinery."

DODGE
of Mishawaka, Ind.

INJECTION MOLDED—This hospital footstool is typical of the products and parts made of MARLEX for hardware, auto, appliance, furniture, housewares, toy, and other industries. (Footstool, Consolidated Molded Products, Scranton, Pa.)

THERMOFORMED—Many items are economically formed of MARLEX sheet: tote boxes, trays, automotive and industrial components, food packages . . . even light, sturdy boats. (7' SPORTYAK®, Woodall Industries, Inc., Detroit 34, Mich.)

BLOW MOLDED—MARLEX blow molding resins provide superior lampshades, containers . . . a variety of large and small components. (Container, HYSPEC by Hydrocarbon, Keyport, N. J.) (Lampshade, Haveg Industries, Bound Brook, N. J.)

By every method . . .
MARLEX* quality assures success

MARLEX high density polyethylenes, ethylene copolymers and tailored resins afford you versatility and outstanding product quality at moderate cost. They enable you to produce items which are durable, tough, light, corrosion proof and rot proof . . . and produce them at low cost. Products made of MARLEX withstand temperature extremes (−180°F to 250°F)... acids, alkalies, oils and greases. Get complete information about MARLEX today! Your inquiry will get prompt attention and an early response.

*MARLEX is a trademark for Phillips family of olefin polymers.

EXTRUDED—Large and small pipe for many uses, electrical conduit, filament and yarn for rope and fabric, sheet or clear film . . . are extruded products made better of MARLEX.

BLOWN FILM—Thin, yet tough, strong and light, MARLEX is used for bulk bags, construction barriers, agricultural and industrial films. (Bag, Crystal-X Corp., Lenni Mills, Pa.)

For more information, see your plastic fabricator, or contact us.

PHILLIPS CHEMICAL COMPANY
Bartlesville, Oklahoma
A subsidiary of Phillips Petroleum Company

PHILLIPS 66 MARLEX PLASTICS

CIRCLE 39 ON READER SERVICE CARD

stainless steel adds sales appeal.
the car designed with stainless steel looks better when you buy it and is worth more when you sell it.

McLOUTH STAINLESS STEEL

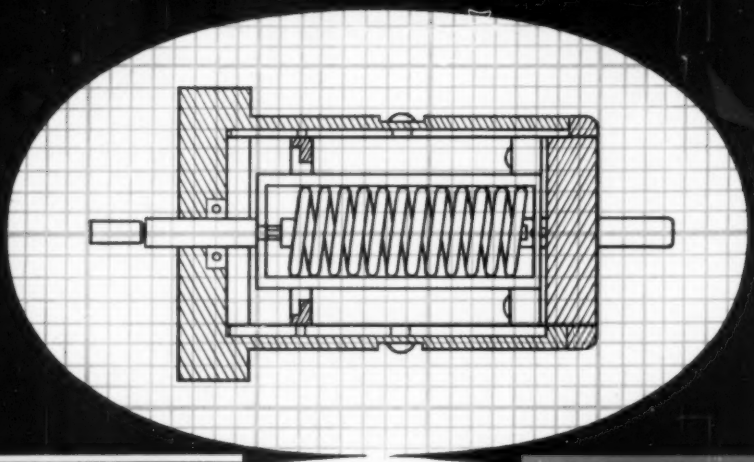
McLouth Steel Corporation · Detroit 17, Michigan

Look for the **STEELMARK** on the products you buy

When you specify

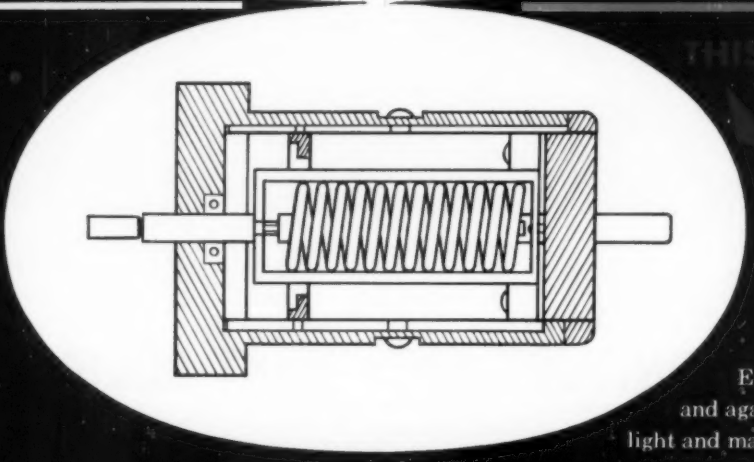
CLEARPRINT "FADE-OUT" PAPER

Drafting costs are cut in half



THIS IS YOUR DRAWING

Quickly and accurately rendered to scale with blue grid lines to guide you. Guide lines are on back of drawing surface enabling you to erase and erase without disturbing them.



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Blue grid lines have disappeared completely giving sharp, easy-to-read copies.

Try Clearprint's perfect working surface with a 2H pencil—then with a pen. Lines are sharp and clear—Erase and draw the lines again and again. Now hold Clearprint to a light and make reproductions. No ghosts! Then test your present sheet.

SPECIAL NOTE

Ask our representative or write us regarding Clearprint's revolutionary new "Pre-Print" which pre-prints your basic standards, typical details, title blocks, and bills of material. Their application to your particular needs can save thousands of dollars in drafting and lettering time!

CLEARPRINT

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TECHNICAL PAPER

FORMS • CHARTS • GRAPHS

"PRE-PRINT" PAPER

THERE IS NO SUBSTITUTE

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1482 - 67th Street, Emeryville, Calif.

☐ Please send me sample Clearprint "Fade-Out" sheets, with prices.

☐ Send me Clearprint samples, with prices, for the following uses:

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☐ Have your representative call at my office to discuss special applications for my particular needs.

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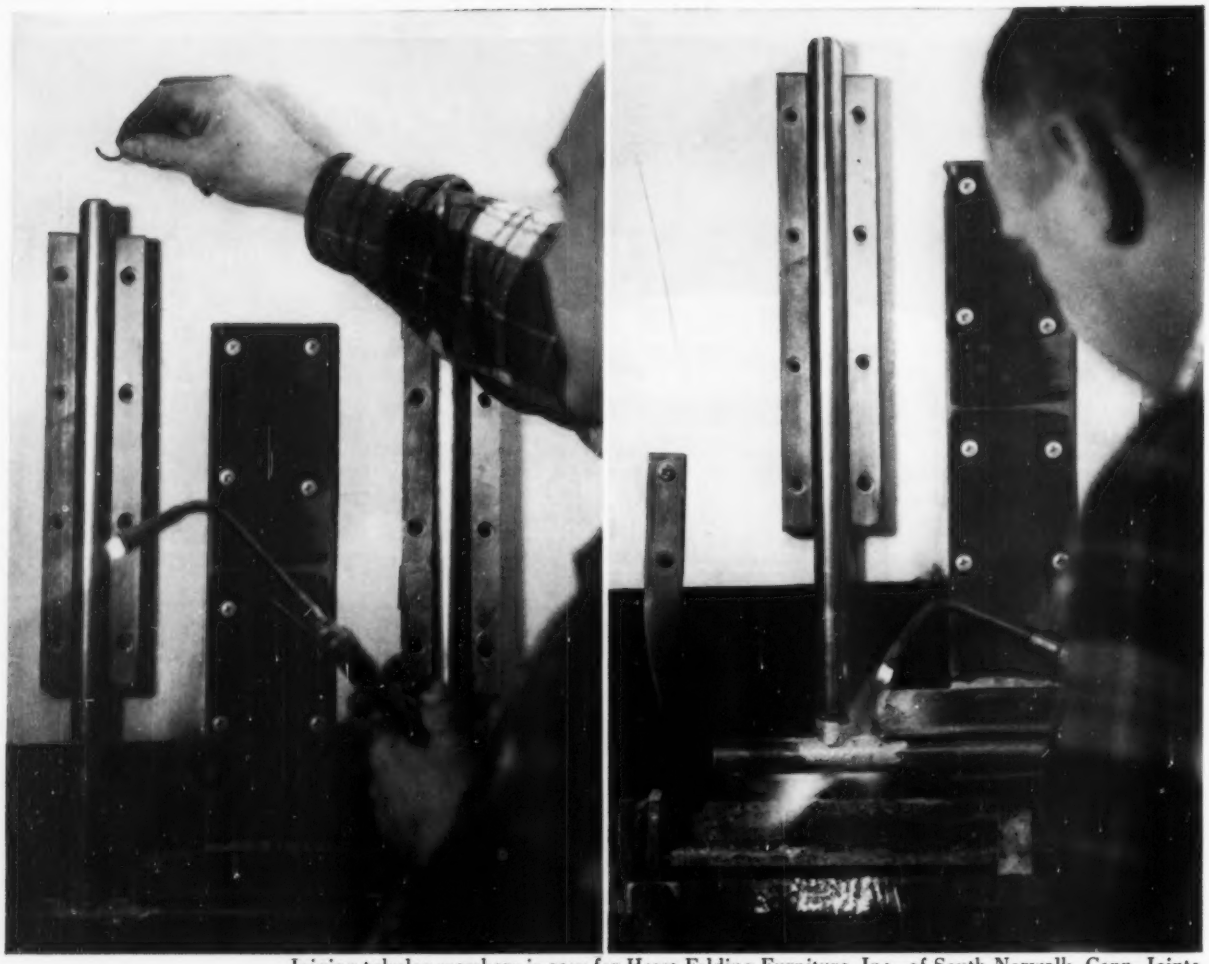


Joining tubular members is easy for Howe Folding Furniture, Inc., of South Norwalk, Conn. Joints are fluxed with Handy Flux, a half-circle preform of EASY-FLO brazing alloy is dropped down the tube and a torch is applied. Result: A smooth, strong joint quickly and economically made.

How Handy & Harman Brazing Alloys

GIVE FOLDING FURNITURE 100% JOINT RELIABILITY

The experience of Howe Folding Furniture, Inc., with silver brazing merits close attention if your operations involve metal-to-metal joining of any kind. Howe manufactures folding metal tables and seats for commercial, industrial and institutional use. You can imagine the hard usage the furniture has to take—yet survive indefinitely.

Some years ago, it was Howe's practice to purchase prefabricated steel tubular assemblies in which the joints were brass brazed on the outside surface. To improve their product, Howe thoroughly tested all joining methods, and decided to go over to silver brazing in their own plant, using Handy & Harman EASY-FLO Alloys 45 and 35. Look at the results:

Complete Joint Reliability: Since adopting silver brazing, Howe has completely eliminated the problem of broken joints.

Economy: Silver brazing costs Howe less than other methods, requires less heating time, simpler equipment, much less cleaning and grinding of joints.

Appearance: Silver brazing provides a smoother, more attractive joint, that can be plated directly.

Is it any wonder Howe says: "We'd stay with silver brazing even if it cost more." There are few fields of industrial activity where the strength, high production rates and economy afforded by the Handy & Harman family of silver brazing alloys cannot improve the look of the balance sheet. Interested in complete details? Just write for a copy of our Bulletin 20 — it's packed with engineering and application data.

Howe cafeteria table-bench is converted to an auditorium bench with backrest in a single motion. Silver brazed joints easily absorb strains.

HANDY & HARMAN

850 Third Avenue, New York 22, N.Y.
PLaza 2-3400

first in silicones

Dow Corning

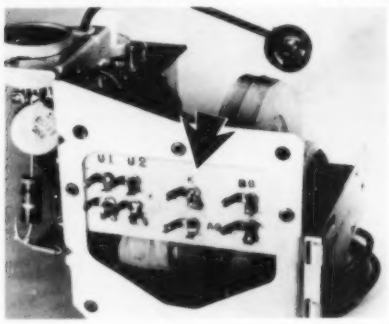
SILICONE NEWS

for design and development engineers • No. 85

FOR BETTER TV

Production of flyback transformers for RCA "Living Color" TV sets is expedited by the use of terminal boards made from silicone-glass laminates produced by Taylor Fibre Company of Norristown, Pa.

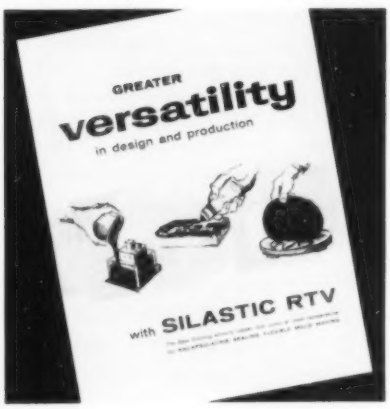
Bonded with a Dow Corning silicone resin, these laminates easily withstand 250 C continuously . . . much higher temperatures for shorter times. Soldering heat doesn't loosen terminals or slow production. Good electric and physical properties, ease of fabrication, and resistance to creep-under pressure of terminal fasteners add up to a top quality high voltage laminate that lends itself to mass production. *No. 242*

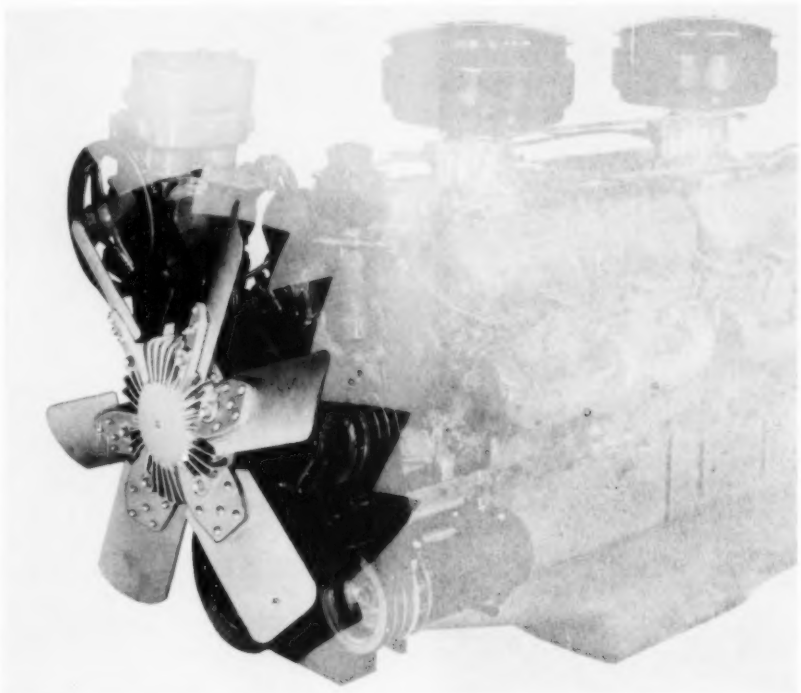


NEW DESIGN TOOL

A rubbery liquid that flows where you want it; a rubbery paste that stays where you put it; a rubbery solid that insulates and cushions, bonds or releases — this is Silastic® RTV.

Silastic RTV is a down-to-earth working tool for design and *(Cont. Pg. 2)*





More Horses, Less Fuel

Fuel consumption is an important element when computing operating costs for trucks, buses, off-the-road vehicles and earth-moving machines. That's why the silicone-filled Thermo-Modulated Fan Drive made by Schwitzer Corporation, Indianapolis, delivers impressive savings. Here's how:

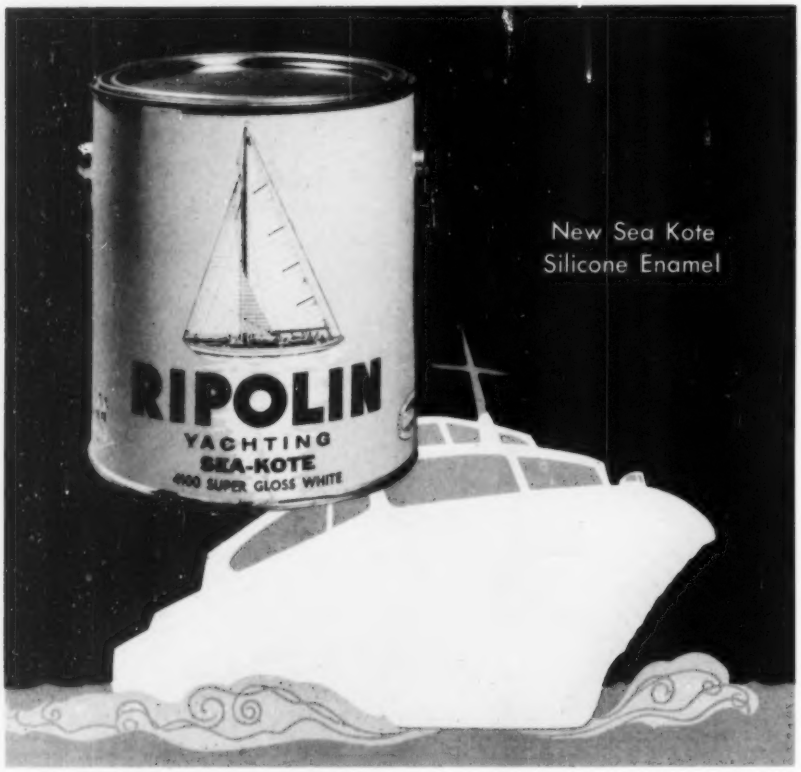
Conventional fan-drives waste fuel because they overwork—cool more than necessary under a majority of operating conditions. Engines can lose up to 10% of total power output just driving the fan when cooling is not required. The Schwitzer fan drive eliminates this waste by relating fan speed to engine coolant temperature.

Because engine power absorbed by a fan is a cubic function of its speed, even slight reductions in fan RPM result in significant fuel savings. Schwitzer claims a 5 to 10% fuel savings and, in addition, attributes reduced maintenance, longer engine life, and a substantial reduction in noise to the use of their drive on commercial vehicles.

Operation of the fan drive is based on simple principles: Torque is transmitted from the input shaft to the fan by the shearing of a fluid film between input and output plates in a silicone fluid filled housing. The control element, which reacts to engine temperatures, varies the thickness of the fluid film between the plates to change fan speed. Naturally, the properties and stability of the fluid medium determine in large measure the accuracy, responsiveness and reliability of the device.

Schwitzer engineers chose a Dow Corning silicone fluid for the viscous drive medium because 1) it is uniquely resistant to breakdown under shear; 2) it retains near-constant viscosity (uniform driving force) over wide temperature spans; 3) it resists oxidation, won't evaporate, thicken or thin out after extensive use.

For more information on how the outstanding properties of silicone fluids can aid you in damping, torque conversion and hydraulic applications, circle . . . *No. 241*



New Enamel Keeps Gloss Longer

You can make your product's brand-spanking-new factory paint job last almost indefinitely by specifying a finish based on Dow Corning silicone resins. A good example of the "extras" you can expect with silicones is found in the new SEA-KOTE marine enamel produced by the Glidden Company, Cleveland, Ohio.

Glidden is confident its new silicone base SEA-KOTE Super Gloss enamel will retain 90% of its original rich gloss after a full year's service above or below waterline in fresh water, or above waterline in salt water. For boat owners, this means no more mid-season refinishing, new convenience and increased satisfaction.

Glidden has tested the enamel in actual use for four years under the worst possible conditions. In addition to repeated exposure to sun, wind, rain and moisture, SEA-KOTE has withstood the ravages of sulfurous gases, sewage infested harbors, oil slicks, exhaust fumes, salt air and exposure to prolonged sunlight. Silicones help keep the paint's slick surface dirt-free . . . toughen the film so it will retain its high gloss, mirror smooth finish almost indefinitely.

If your product could use a coat of beauty that lasts like a coat of armor, it will pay you to investigate the ever-increasing number of silicone-based baking enamels and air dry finishes offered by leading paint formulators. For more information and list of sources, circle . . . . *No. 244*

new literature on silicones

Electronic Engineer's Guide describes all the silicone products that contribute to realiability, miniaturization and environmental protection of electronic components. From satellites to seismographic instruments, this 16-page electronics engineer's guide describes the various forms of silicones that help improve design. *No. 245*

Space Age Silicones are described in thirty typical application stories. Utilization of silicone compounds, fluids, lubricants, protective coatings, rubbers, resins, potting materials and sealants are illustrated for your consideration. This valuable brochure offers solutions to many problems encountered in designing space age aircraft and ground support equipment. *No. 246*

Four Simple Steps to making silicone rubber molds for short run castings are described in an article reprinted from PRODUCT ENGINEERING. Silastic RTV, the fluid silicone rubber that cures at room temperature, makes it possible to produce flexible molds and patterns for casting metal or plastic parts, even with most intricate detail, cheaply and quickly. An ideal means of making prototype parts. *No. 247*

Does silicone rubber resist solvents, chemicals, oils, fuels, and other fluid media? Sometimes it does and sometimes it doesn't. New 20 page bulletin lists the effects of over 250 fluids from coffee to jet fuel on Silastic silicone rubber after immersion for varying times and temperatures. For free copy, circle . . . . . *No. 248*

SILASTIC RTV *(Continued)*

production engineers. When poured or squeezed into place, this silicone rubber cures at room temperature to a tough, resilient solid that has the resilience of rubber *plus* the indestructibility of its silicone ancestors. Silastic RTV's physical and electrical properties are unaffected by heat, cold, moisture, ozone and corona.

A just-released eight-page brochure illustrates and gives details about Silastic RTV and its applications. Included also is a Selector Guide which describes the properties of each of the various RTV systems. To obtain your copy, circle . . *No. 243*

Dow Corning Corporation, Dept. 5228, Midland, Michigan

Please send me: 241 242 243 244 245 246 247 248

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SILICONE NEWS is published for design and development engineers by

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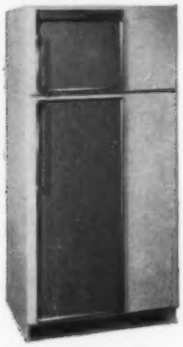
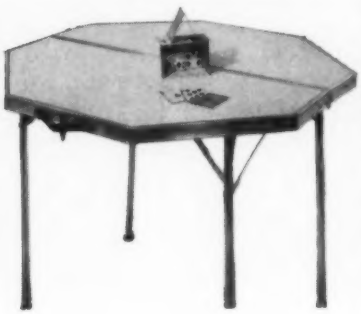


Masland Duran
CLAD
vinyl finish



On just about any product this built-in finish reduces manufacturing costs...boosts saleability

Take the matter of costs. Since Masland Duran Clad is an *integral* finish, you can work with pre-finished parts. That means you can often do away with the need for baking and spraying. No new processing equipment needed, either. This colorful, handsomely designed vinyl can be permanently laminated to metal . . . and cut, crimped, drilled or deep drawn without distortion or marring. As for saleability . . . there isn't anything that excels color-bright, easy-to-clean Clad for attracting immediate and favorable attention to your product. For samples, mail this coupon.

Industrial Products Division

THE MASLAND DURALEATHER CO., Dept. PE-H, Philadelphia 34, Pa.

SEND FOR SAMPLES TODAY

The Masland Duraleather Co., Dept. PE-H,
Amber & Willard Sts., Philadelphia 34, Pa.

Please send information and samples of Clad.

Name_____ Title_____

Company_____

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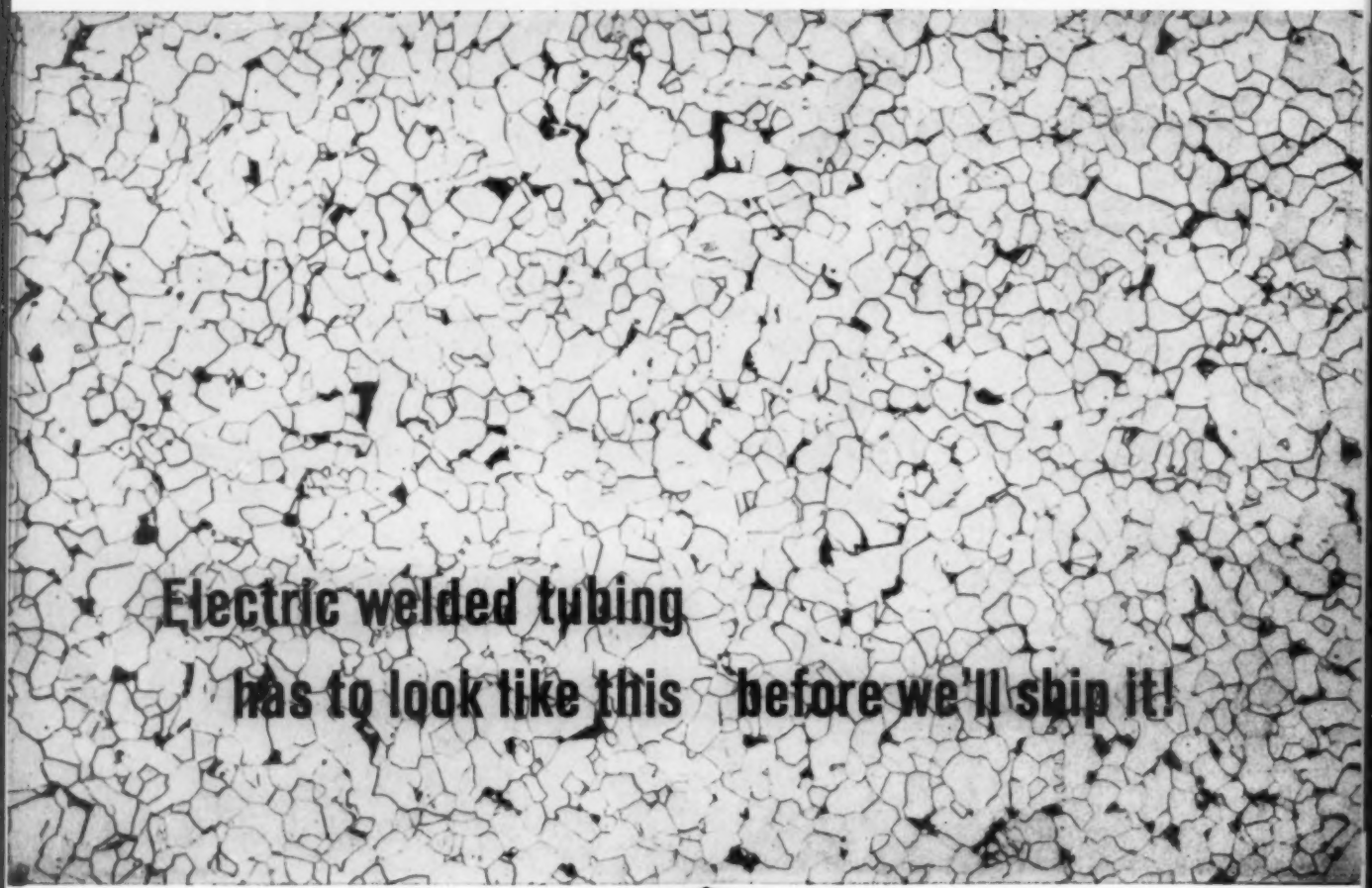
This mark tells you a product is made of modern, dependable Steel.

Portrait of a perfect weld Magnification—100X; Etch-Picral Nital



In this photomicrograph of a section of USS National Electric Resistance Welded Steel Mechanical Tubing the weld section runs right down through the center of the picture above the arrow. The consistency of structure between the weld area and the rest of the tube shows that USS National Welded Mechanical Tubing has an important attribute—dependability.

Mechanical tubing must be flawless. It's used in so many critical applications that demand utmost strength, excellent surface inside or outside and extreme dimensional accuracy. National Tube's production methods assure this high quality.

Important advantages of USS National Welded Mechanical Tubing are its ability to reduce machining operations to a minimum or eliminate them entirely. For a given weight, it withstands more load than any other section. It resists bending stresses equally in all directions. In torsion, it provides maximum material distribution.

USS National Welded Mechanical Tubing is available in cold-drawn or hot-rolled sizes ⅜″ thru 5½″ and in wall thickness .035″ to .250″. All sizes can be obtained from National Tube Distributors located throughout the country. They will gladly show how tubing can reduce your costs. *See your USS National Tube Distributor.* *USS and National are registered trademarks*

National Tube Division of United States Steel

USS

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors • United States Steel Supply Division • United States Steel Export Company, New York

SQUARE D NORpak
—A SIMPLER, FASTER, STATIC CONTROL!

NORpak is a significant advance in the field of static switching. Like other static systems, **NORpak** performs the functions of machine tool relays, stepping relays, latching relays and timers —all without contacts or motion of any kind.

Like other static systems, **NORpak** is ideal for applications where speed is important—where reliability and long life are essential—where conditions make conventional magnetic devices impractical.

But unlike other static switching systems, NORpak offers these important advantages

EASIEST TO APPLY

The transistor NOR unit is the basis of **NORpak.** All logic functions—AND, OR, NOT, MEMORY—can be accomplished with combinations of this single NOR unit.

NORpak is *not* complicated — it's easy to apply to conventional circuits. Units are color-coded for quick identification. Simple DC circuit eliminates worry about phase relationships.

EXTRA DEPENDABILITY

NOR units have been time-tested in computer use for years. They are not subject to wear, will give top performance indefinitely, and provide unfailing circuit fidelity.

SIMPLE TO USE

Optional monitor lights give visual evidence of proper performance. Simple dynamic sequence tester checks individual NOR units in operation.

UNMATCHED SPEED

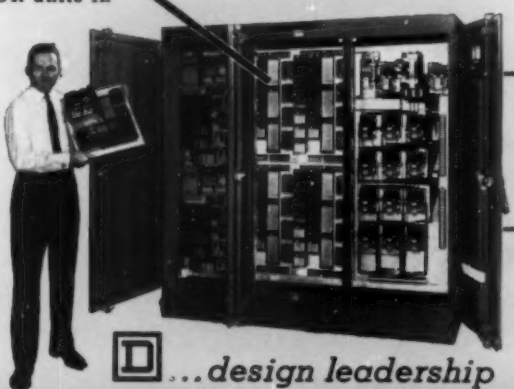
NORpak provides switching at rates up to 25,000 per second—faster than any other industrial static system.

EXPERT APPLICATION HELP

Field specialists, factory-trained in all aspects of **NORpak** can give you on-the-spot answers to any application questions.

SMALLEST COMMERCIAL PACKAGES

NORpak is available in the form of individual components, or in completely engineered systems. Components are offered in 6 and 20 paks, require only 1/4th the equivalent relay panel space, and weigh less than components of other static systems.



NORpak is available as individual components for application to specific control functions, or as completely engineered systems ranging from the smallest to the largest panels

Write for the complete story on NORpak —its theory, application and operation... Square D Company, 4041 North Richards St., Milwaukee 12, Wisconsin

...design leadership

SQUARE D COMPANY

wherever electricity is distributed and controlled

CIRCLE 47 ON READER SERVICE CARD 47

Familiar product . . . new use

In the hands of experts, a well-known product has found a new use, brought about by today's fast moving technology. A spacer with electrical insulating and special mechanical properties was required for this stud-mounted power transistor. CDF solved the problem with paper phenolic rolled tubing, a long-established grade. Fabrication of the spacer is accurate and low cost on automatic screw machines.

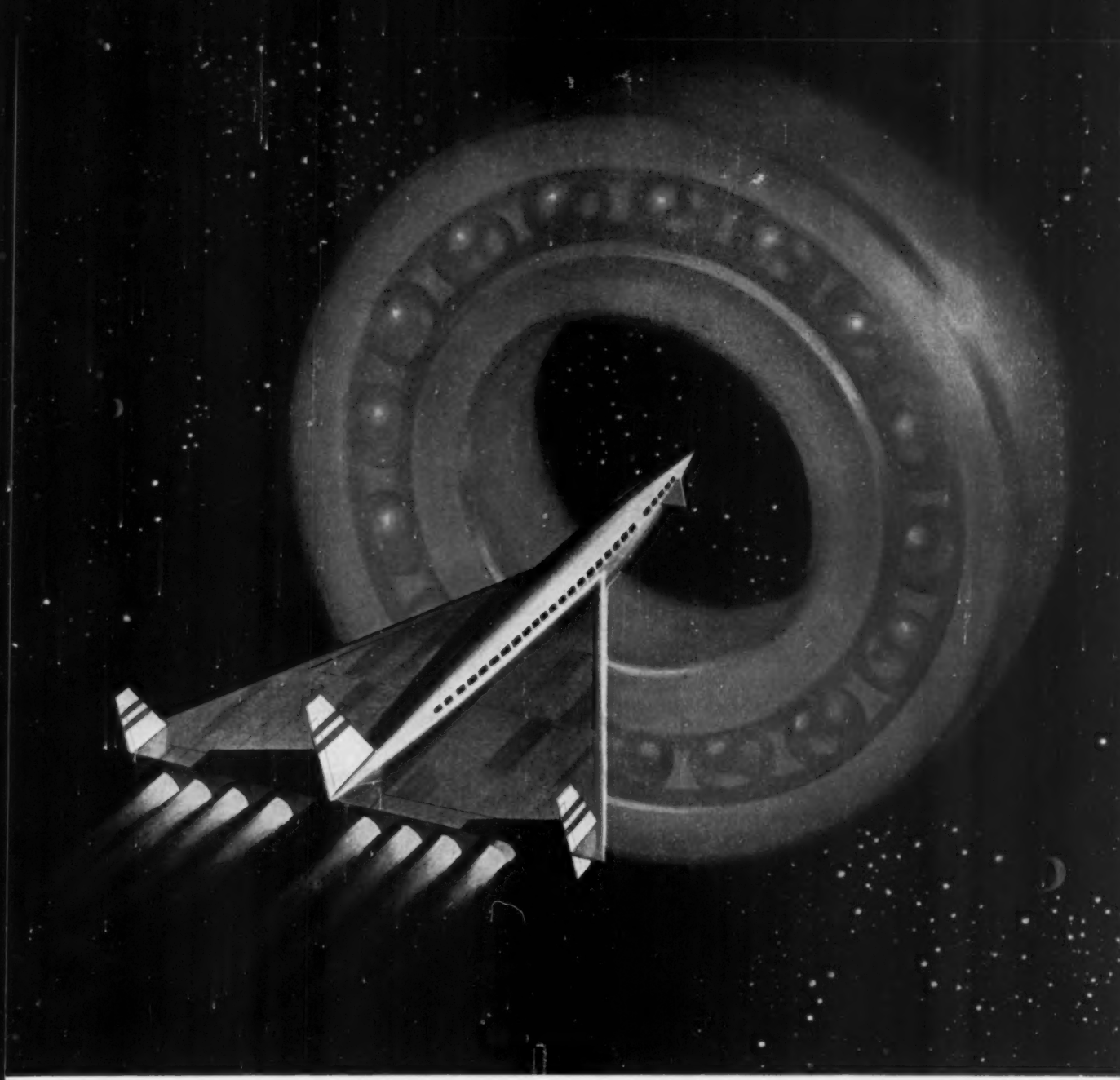
Result: Reliability is assured through use of a time-tested and proven material, while costs are kept to the minimum.

A few facts on the tubing: (1" x 1⅛")

Dielectric strength, perp., vpm	400
Min. density	1.12
Water absorption, %	3.0
Axial compression, psi	13,000

CDF® **CONTINENTAL-DIAMOND FIBRE**

CONTINENTAL-DIAMOND FIBRE CORPORATION, NEWARK, DELAWARE • A SUBSIDIARY OF THE Budd COMPANY



BEARING WITH A RED HOT FUTURE

SKF MOTION ENGINEERING

Advanced ball and roller bearing technology

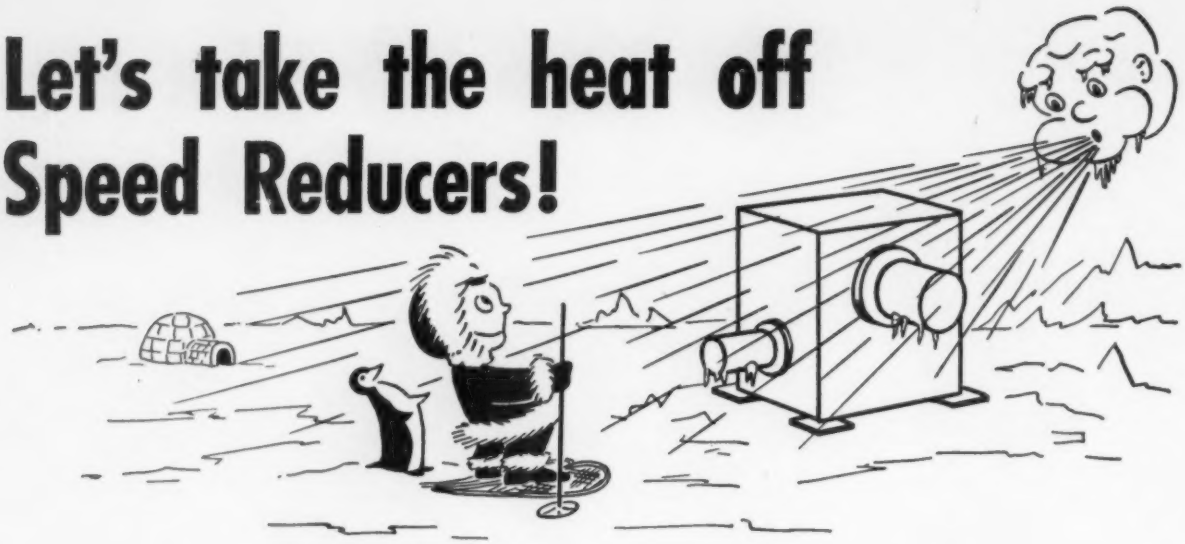
On special test equipment in SKF's research laboratory, experimental ball and roller bearings are run at temperatures up to 1000° F and above—conditions under which steel becomes red hot and loses its strength, while conventional lubricants burn or boil away. To meet these problems, bearings made of special heat-resisting alloys and exotic new materials are tested and evaluated. New ideas in design and new approaches to lubrication are constantly being investigated.

Bearings to resist extremely high temperatures are needed for improved, high performance jet engines, gas turbines and other equipment. Special SKF bearings have been tested successfully in environments at about 1000° F. Under certain conditions of operation, much higher temperatures are practical.

Research like this is your assurance that SKF will always keep pace with demands for the highest possible performance in all major types of rolling contact bearings —ball, cylindrical roller, spherical roller, tapered roller and precision miniature. SKF Industries Inc., Philadelphia 32, Pa. 6103

CIRCLE 49 ON READER SERVICE CARD

Let's take the heat off Speed Reducers!



A worm gear speed reducer is one of the toughest little customers in captivity. It reduces speeds day-in, day-out, with little complaint. While it works long and hard, it has limitations—set by ratio, center distance, RPM, mechanical and thermal HP ratings, etc. And, depending upon how precisely it was selected and fitted to the job requirements, it will do what it has to do.

But sometimes it's forced to play outside of its league. It must cope with job requirements that vary from here to there—normal 8 to 10 hour service without recurrent shock, the same length of service where there is some shock loading, continuous low-speed service and almost countless others. But the thing that really puts the pressure on reducers, the thing that's lurking in *every* set of job requirements—is h-e-a-t.

When you exceed the thermal capacity of a reducer for more than an hour or so, excessive temperature thins the lubricant resulting in wear; material, bearing and oil seal failures; etc. Of course, the proper lubricant will help but it can't cure the continuing problem of excessive heat.

So how can we lick this toughy? One way is to build the reducer housing oversize, big enough to radiate the heat away and keep temperatures down. But this type sticks out in aisles, louses up compact designs and barks shins. Then, we might try a smaller housing complete with fins on it to dissipate the heat. If this still doesn't work, another trick is to use a reducer with capacities and ratings a step above the ones we need. This is sending a man to do a boy's job. It's impractical, inefficient and costly. There *has* to be an easier, better, saner and cheaper way to do it. And there is!

In certain cases, where the size and type of reducer permits and where we can gain enough in thermal HP rating to keep heat generation in bounds, Cone-Drive Gears does it with fan-cooling.

What's that? Simple. Just add a fan to the worm shaft plus the necessary air shields, fan cover, etc., and presto!—heat is no longer a problem. The air shields direct the fan-pushed air over the fins on the lower portion of the reducer. The fins are shaped and spotted to guide the air stream where it is needed. Thermal HP ratings are boosted tremendously, as high as 147% above those of standard reducers in some cases! Those over-worked, over-heated reducers will now do the job you bought them to do.

Other advantages? They're here in abundance. The size of the reducer stays the same. All parts on a Cone-Drive fan-cooled reducer are 100% interchangeable with parts for standard reducers. Oil capacity is identical. Shields are quickly removed without disconnecting the reducer. (This is important where severe operating conditions make periodic cleaning necessary). The reducer can also be operated *without* fan-cooling just by taking off the fan and shields.

This simple addition to standard Cone-Drive HU speed reducers might be just your answer—might save you some money. Write for Cone-Drive's Bulletin CD-218. It will tell you all about the full line of Cone-Drive double-enveloping worm gear reducers as well as the fan-cooled kind. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12, Mich.

Giant Radar Guards Our Shores...

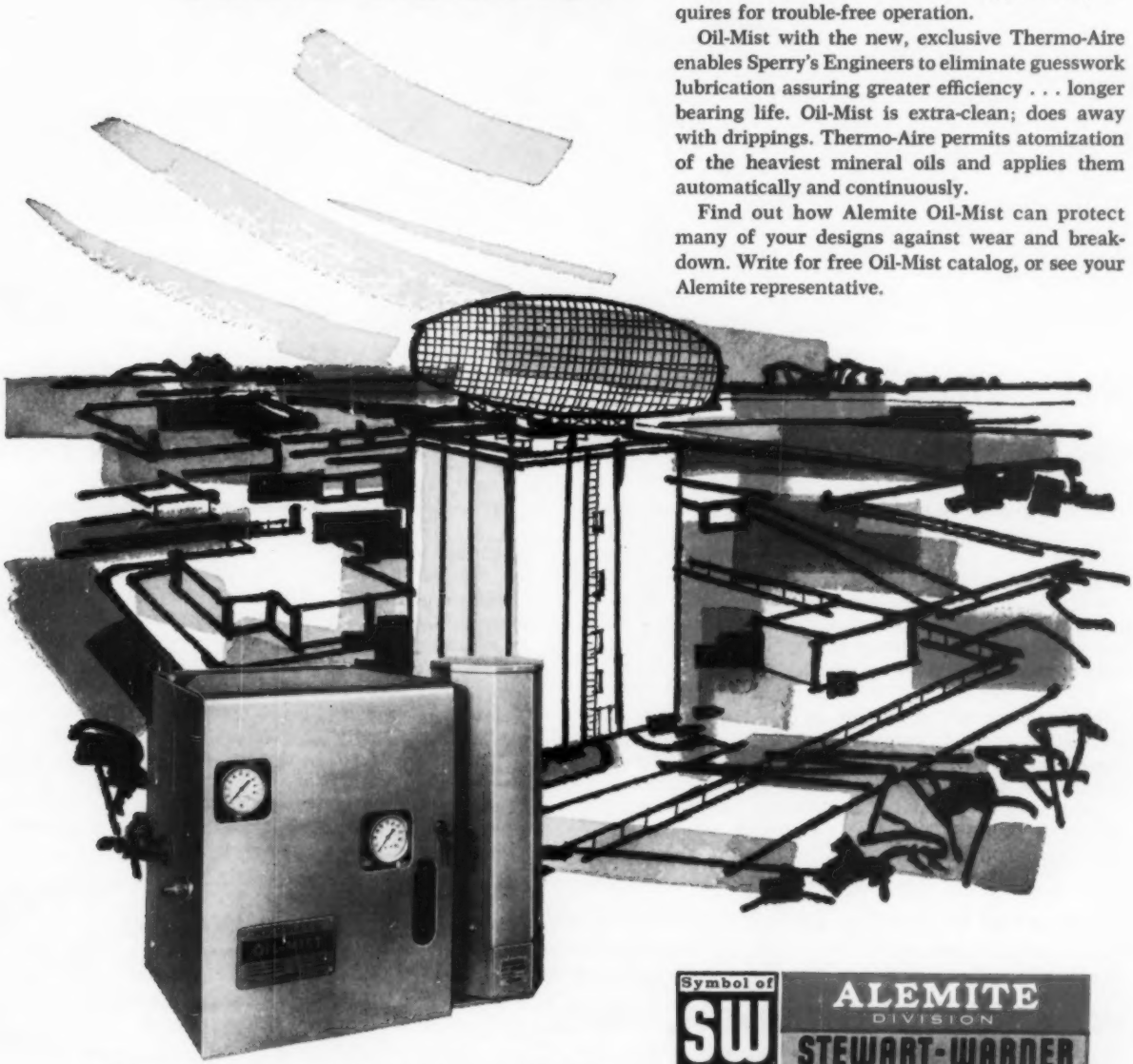
ALEMITE OIL MIST WITH THERMO-AIRE® GUARDS ITS GIANT BEARING!

The FPS-35 radar at Montauk Air Force Station, designed and developed by Sperry Gyroscope Company, is one of the largest in the world. The huge 140,000-pound antenna assembly rides on a precision-built azimuth bearing with an outside diameter of 160.500-inches. This bearing is machined to fit its retainer with a total looseness of no more than 0.006 of an inch.

10-years of continuous operation, with only four 24-hour shutdowns a year for servicing maintenance, is the life design-requirement for this antenna. For the all-important job of lubricating this azimuth bearing, Sperry Engineers selected Alemite Oil-Mist with Thermo-Aire. Oil-Mist provides the *fully-automatic, continuous, all-over* lubrication protection this bearing positively requires for trouble-free operation.

Oil-Mist with the new, exclusive Thermo-Aire enables Sperry's Engineers to eliminate guesswork lubrication assuring greater efficiency . . . longer bearing life. Oil-Mist is extra-clean; does away with drippings. Thermo-Aire permits atomization of the heaviest mineral oils and applies them automatically and continuously.

Find out how Alemite Oil-Mist can protect many of your designs against wear and breakdown. Write for free Oil-Mist catalog, or see your Alemite representative.



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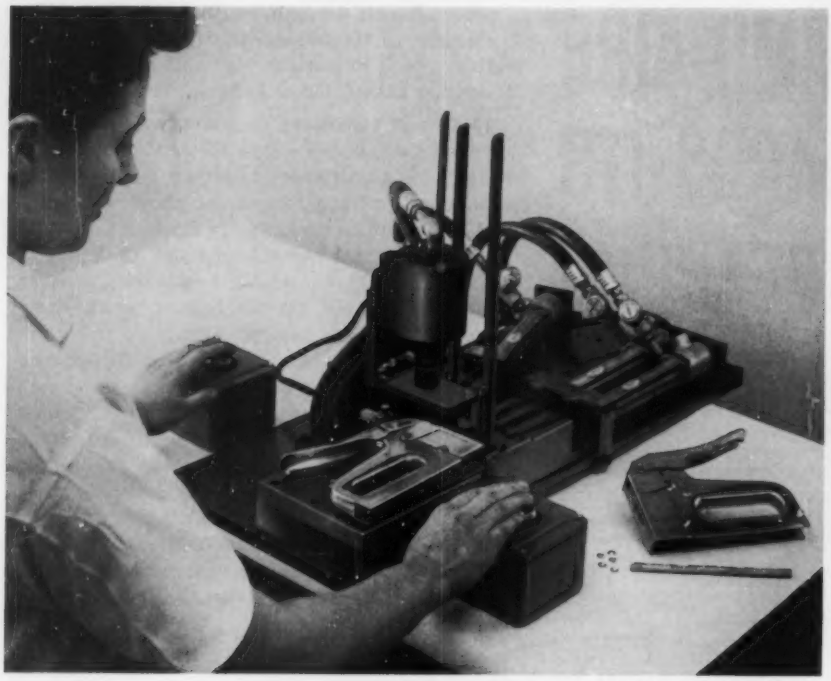
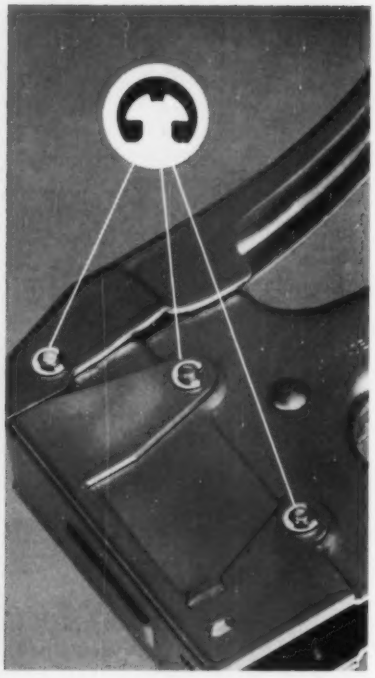
Here's how ARROW FASTENER Co. gets Truarc® Retaining Rings FREE!





U.S. PAT. NO. 2,837,812

Mechanized Ring-O-Mat® designed by Truarc Engineers doubles stapler production for saving of $2500/year

Arrow Fastener Co., Inc., Brooklyn, N. Y., uses three Truarc Series 5144 reinforced E-rings to secure components in its Model T-50 compression stapler. Originally, Arrow operators installed the rings by hand with conventional applicators and dispensers. Fast? Sure — but Truarc engineers suggested to the company how the job could be done even faster and more economically by mechanizing the entire ring assembly operation.

Working closely with the Arrow engineering and production staff, Truarc mechanization engineers designed the unique Ring-O-Mat shown above. The unit installs the three E-rings in a single operation, twice as fast as the former hand method. Savings with the equipment are $2500 a year — enough to pay for all the rings the company uses!

Here's how the Ring-O-Mat works. The Truarc rings are supplied in tape-wrapped Rol-Pak® cartridges which are loaded on vertical magazine rails at the center of the unit. To install the rings, the operator merely places the stapler in a nest at the front and pushes the control buttons . . . the Ring-O-Mat does the rest! Applicators connected to the air cylinders grasp the bottom ring in each stack and move forward, seating the rings in accurately located grooves pre-cut in pivot pins extending through the body of the stapler. When the rings are fully seated, the applicators are withdrawn automatically and the operation is completed. Simple, fast, fool-proof — a typical example of how Truarc retaining rings lend themselves to mechanized assembly. A good example also of how you get *more* than a fastener when you buy Truarc!

Interested in getting your retaining rings FREE?

Bulletin 459-13 describes a number of assembly techniques for mass-production ring installation. Write for a copy or see your Truarc representative.

WALDES KOHINOOR, INC.

47-16 Austel Place, Long Island City 1, New York

61-5

Photodrawings on CRONAFLEX®:

Easy new way to communicate complex design data—at lower cost!

Draftsman adds assembly detail to complete master original photodrawing. Photographic images insure accurate interpretation of data, also mean tremendous savings in time and money.

Designing advanced computer prototypes, engineers at Remington Rand's Univac Division faced the problem of transmitting complex specifications to customers and production facilities—many of them overseas. Needed were drawings graphic enough to minimize misinterpretation, yet adaptable to progressive modification and refinement.

The solution: photodrawings on CRONAFLEX® Engineering Reproduction Films. In this technique, a photographic image is used as the main body of an engineering drawing and assembly detail is added by a draftsman. Not only does the new method make complicated specifications easily understandable, it has already cut drafting time—and costs—drastically.

Says Theodore Warzel, Chief of Univac Division's Photographic Department: "We actually turn out completed drawings about 25 times faster than we used to! And the excellent erasability of CRONAFLEX permits numerous revisions to be made—a must in critical development work—with no damage to its fine drafting surface."

Results like these are typical of the performance of CRONAFLEX in situations where other materials promote waste and inefficiency by failing to fit a need exactly. To learn how these versatile films can meet your own requirements, clip and mail the coupon today.

E. I. du Pont de Nemours & Co. (Inc.)
Photo Products Department PE 10
Wilmington 98, Delaware

Please send me, without obligation:

- ☐ Information on the full line of CRONAFLEX films
- ☐ Details on photodrawing technique described here

Name _____

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DU PONT
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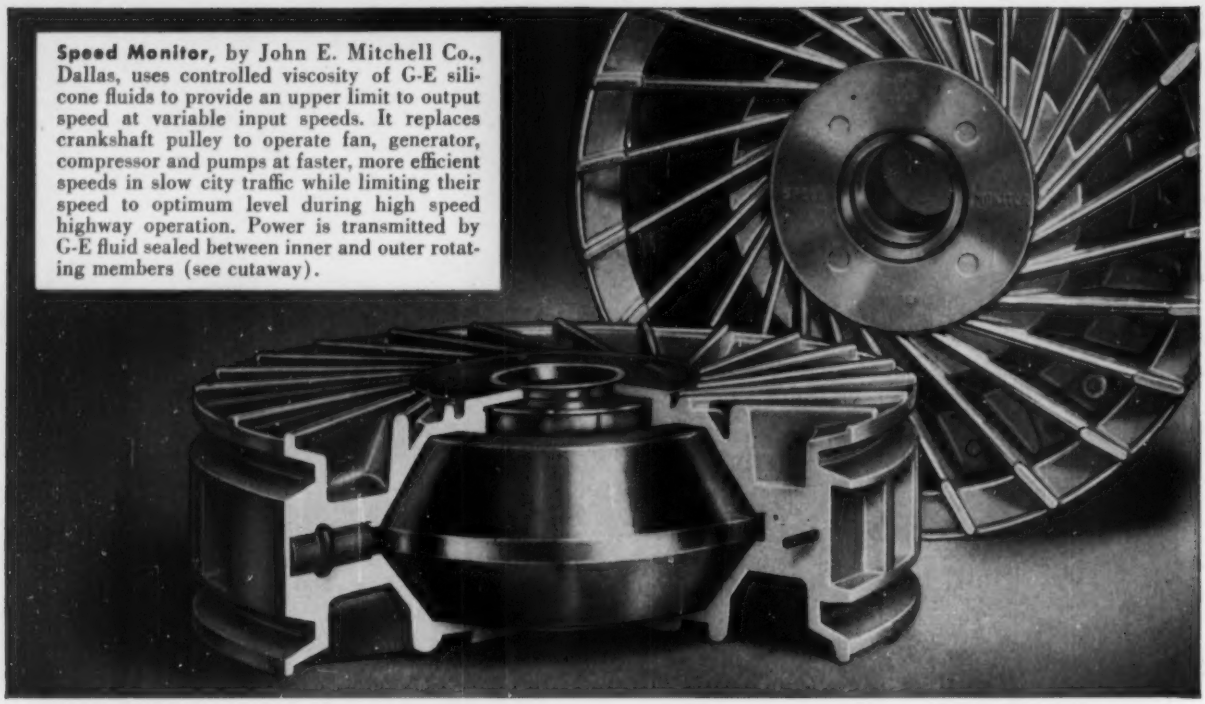
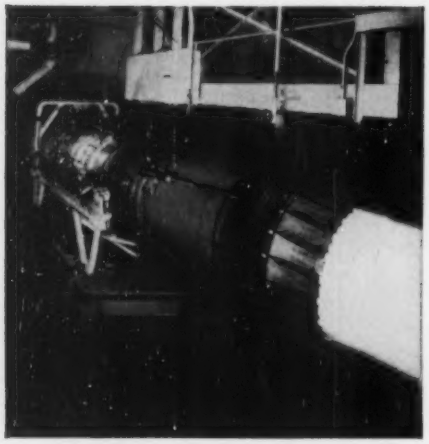
Better Things for Better Living
. . . through Chemistry



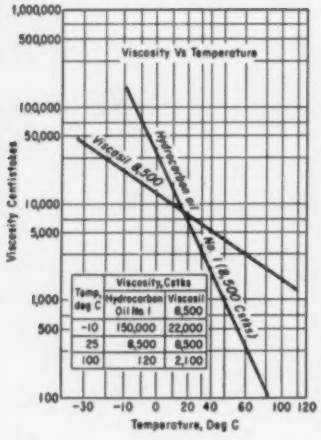
Speed Monitor, by John E. Mitchell Co., Dallas, uses controlled viscosity of G-E silicone fluids to provide an upper limit to output speed at variable input speeds. It replaces crankshaft pulley to operate fan, generator, compressor and pumps at faster, more efficient speeds in slow city traffic while limiting their speed to optimum level during high speed highway operation. Power is transmitted by G-E fluid sealed between inner and outer rotating members (see cutaway).

GENERAL ELECTRIC SILICONE FLUIDS

for reliable performance under tough operating conditions

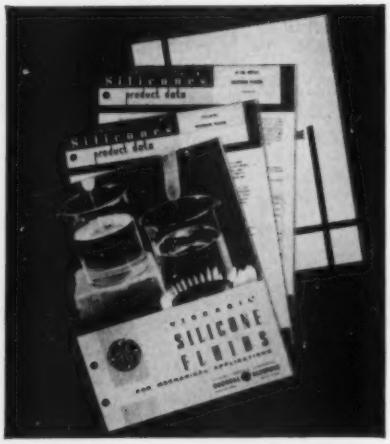


Thermal stability. The outstanding thermal and oxidative stability of G-E silicone fluids, over an operating temperature range of —100°F to 600°F, makes them suitable for such rigorous applications as jet engine lubricants and aircraft hydraulic fluids. G-E Versilube fluids give unequalled performance at high temperatures and are comparable to other hydraulic fluids in moderate ranges.



Temp. deg C	Viscosity, Cstks	
	Hydrocarbon Oil No. 1	Viscasil 6,500
-10	150,000	22,000
25	6,500	6,500
100	120	2,100

Nearly constant viscosity over wide temperature range. G-E silicone fluids exhibit very small changes in viscosity with wide temperature variations. This makes them ideal for many mechanical applications, including fluid drives, dash pots, vibration dampers, timers, shock absorbers, or wherever constant viscosity is needed.



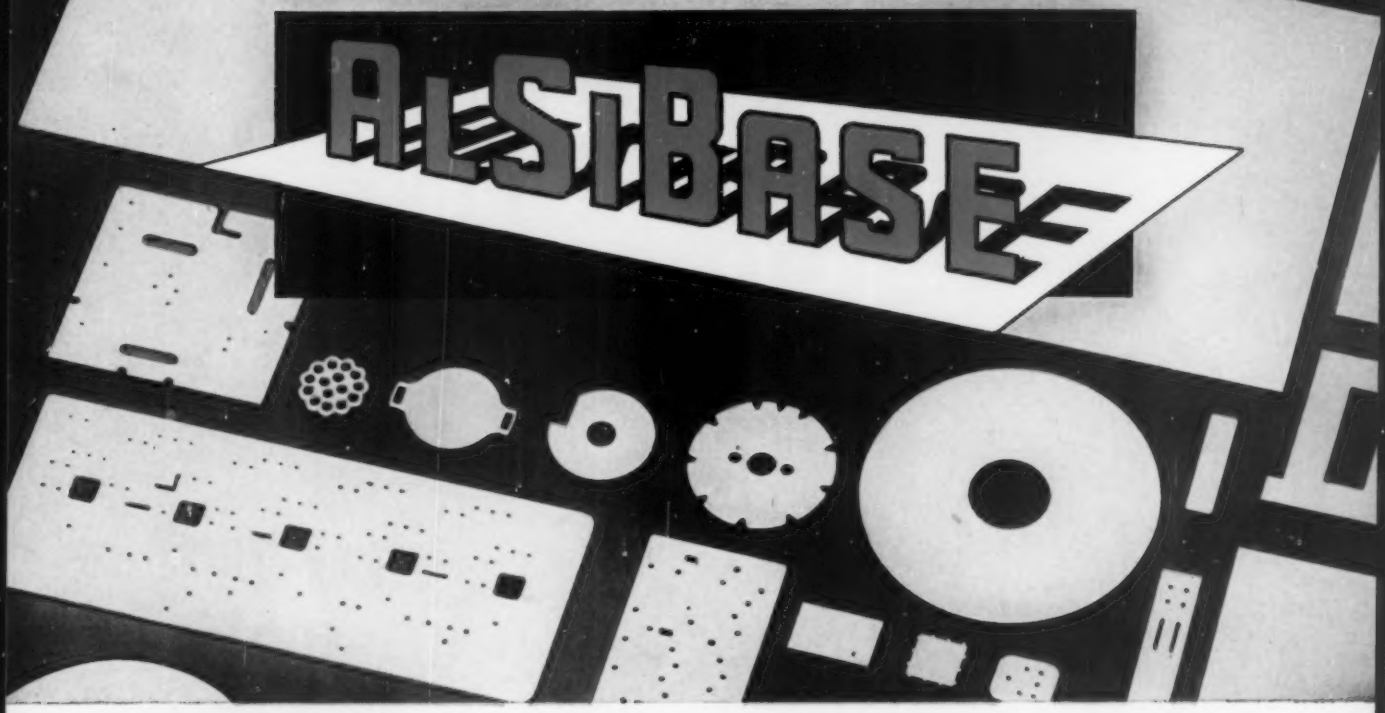
Get the complete story. These bulletins give complete technical data on the G-E silicone fluid line and describe many of the ways in which designers are taking advantage of their outstanding properties. For your free copies, write to Department A853, General Electric Company, Silicone Products Department, Waterford, N. Y.

GENERAL ELECTRIC

CIRCLE 55 ON READER SERVICE CARD→

Introducing

AlSiBase



AlSiBase

improved ceramics result from a new method of fabrication.

Favorable characteristics include:

1. Fabrication of thin sections especially suited for substrates. Marked improvement has been made in flatness or camber control.

2. Flatness and dimensional accuracy within normally accepted ranges without grinding expense, contaminants or scratches. However where especially strict requirements must be met, AlSiBase can be furnished both ground and polished at commensurate cost.

3. Ability to fabricate holes, slots, serrations to tighter than usual tolerances without machining after firing.

4. A superior and uniform surface especially adapted to economical coating or metalizing. Surface finish in 10-25 microinch range is available without grinding or polishing.

5. AlSiBase has exceptional dielectric strength in thin sections. Measurements made to date on AlSiBase in the new thin sections indicate better dielectric strengths than those of similar ceramic formulations processed by conventional methods and tested on ¼" thick discs in accordance with A.S.T.M. D 667-44. A typical AlSiBase design in alumina had a dielectric strength up to 2000 ACV/mil at 10 mil thickness.

May we see your prints on parts where this might apply?

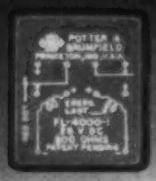
A subsidiary of Minnesota Mining and Manufacturing Company

AMERICAN LAVA CORPORATION

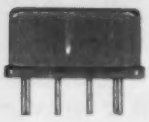
CHATTANOOGA 5, TENN.
60TH YEAR OF CERAMIC LEADERSHIP

For service, contact American Lava representatives in Offices of Minnesota Mining & Manufacturing Co. in these cities (see your local telephone directory): Boston; Newton Center, Mass. • Chicago: Bedford Park, Ill. • Cleveland, Ohio • Dallas, Texas • Los Angeles, Cal. New York: Ridgefield, N. J. • Philadelphia, Pa. • St. Louis, Mo. • St. Paul, Minn. • So. San Francisco, Cal. • Seattle, Wash. All other export: Minnesota Mining & Manufacturing Co., International Division, 99 Park Ave., New York, N. Y.

a New and superior latching P&B relay



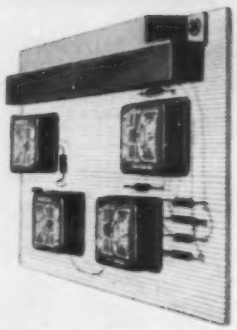
LIES FLAT FOR GREATER PACKAGE DENSITY, HIGHER PERFORMANCE



This DPDT, permanent magnet, latching relay is superior on these counts: (1) shorter height for maximum compactness between stacked circuit boards; (2) greater sensitivity (80 milliwatts); (3) better vibration resistance (30 g to 2000 cps); (4) better shock resistance (100 g).

Designated the FL Series, this relay meets all applicable sections of MIL-R-5757D, MIL-R-6106C and ABMA #PD-R-187.

Call your nearest P&B representative today for complete information about the whole P&B family of microminiature relays.



Printed circuit board using 4 FL relays was designed by the Martin Company, Orlando, as part of ground support equipment for a major missile project.

FL SERIES SPECIFICATIONS

Contact Arrangement: DPDT

Shock: 100 g for 11 milliseconds with no contact openings.

Vibration: .195; max. excursions, 10 to 55 cps, 30 g from 55 to 2000 cps. No contact openings.

Linear Acceleration: 400 g minimum with no contact openings.

Pull-In: 150 milliwatts, approx. (standard) at 25°C. coil temperature.

80 milliwatts, approx. (sensitive) at 25°C. coil temperature

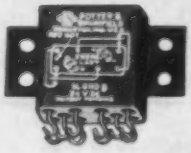
Operate Time: 3 milliseconds max. at nominal voltage at 25°C. coil temperature

Dimensions: .485" high, 1.100" long, .925" wide

THERE'S A P&B CRYSTAL CASE RELAY FOR YOUR PROJECT

Diode in relay case is used for arc suppression in special applications. Four diodes form full-wave bridge rectifier for 400 cycles.

Non-latching or latching relays in conventional crystal cases with or without shoulder brackets, studs or mounting plates. All types of terminals are available.



Terminals spaced on .200" grids are available on all P&B microminiature relays. These carry a "G" suffix (SCG and SLG) and are .890" high, .800" wide, .400" deep, max.

These 3 relays are shown slightly reduced in size.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONICS PARTS DISTRIBUTOR

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY • PRINCETON, INDIANA

IN CANADA: POTTER & BRUMFIELD, DIVISION OF AMF CANADA LIMITED, GUELPH, ONTARIO

Mr. Design Engineer:

Is high torque strength of interest to you?

Take a look at the reinforced Plaskon® Nylon specified by a prominent manufacturer for their newest outboard propeller. The material is Nylafil G-3 — Plaskon Nylon reinforced with glass fibers under carefully controlled conditions by the Fiberfil Corporation, Warsaw, Indiana.

They chose this material because of its outstanding tensile and flexural strength which enables it to meet the high torque requirements of an outboard propeller. Also important are its excellent resistance to corrosion and electrolysis, outstanding impact resistance, light weight, improved dimensional stability, and fine resistance to abrasion (propellers are tested by running over sand bars and oyster beds).

Even if your field isn't marine engineering, these properties should be of interest to your particular design problem. Let our Applications Engineering Group work with you — write our Nylon Design Department.

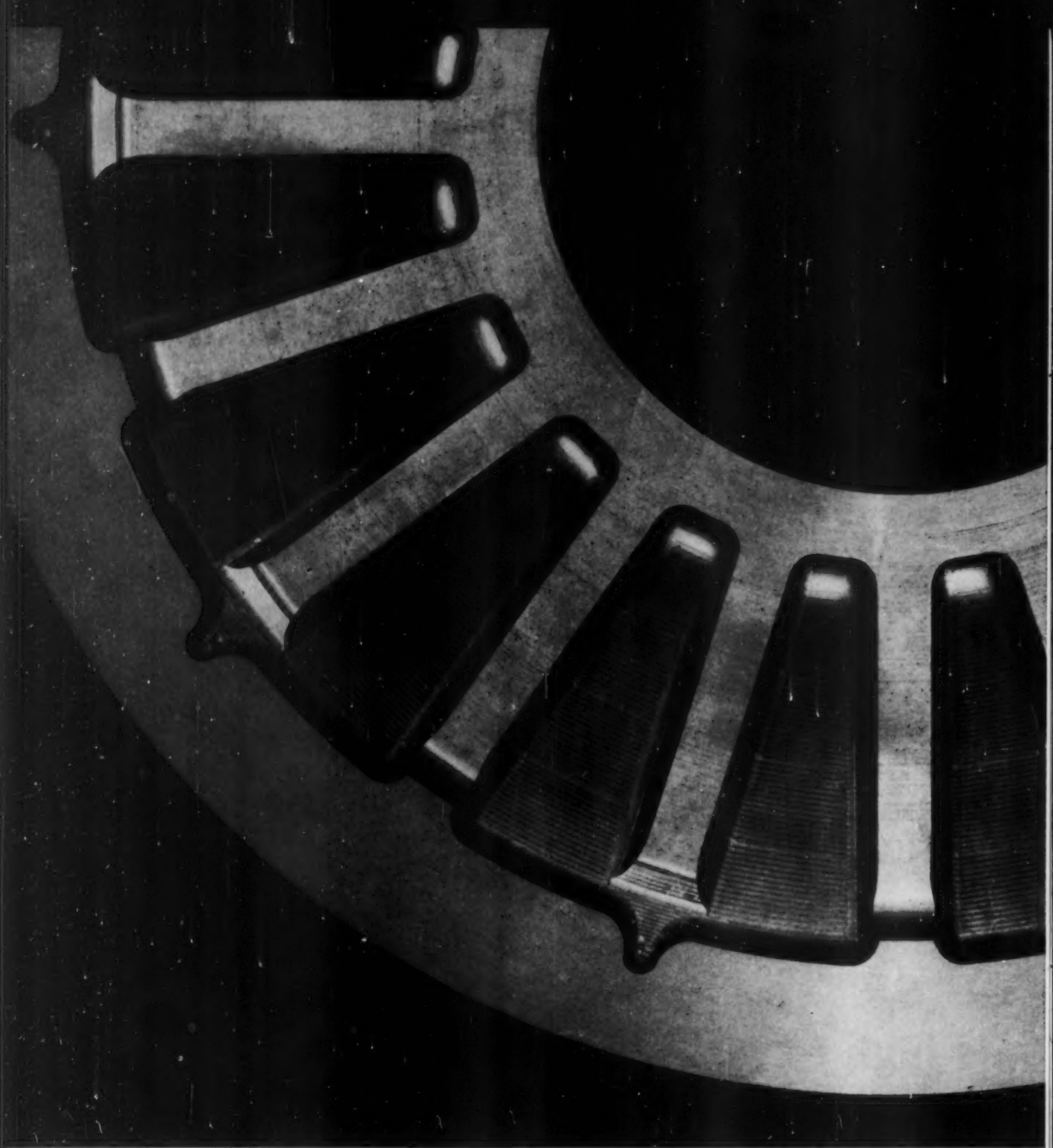
Allied Chemical

BASIC TO AMERICA'S PROGRESS

PLASTICS DIVISION
40 Rector Street, New York 6, N. Y.

←CIRCLE 56 ON READER SERVICE CARD

CIRCLE 57 ON READER SERVICE CARD 57

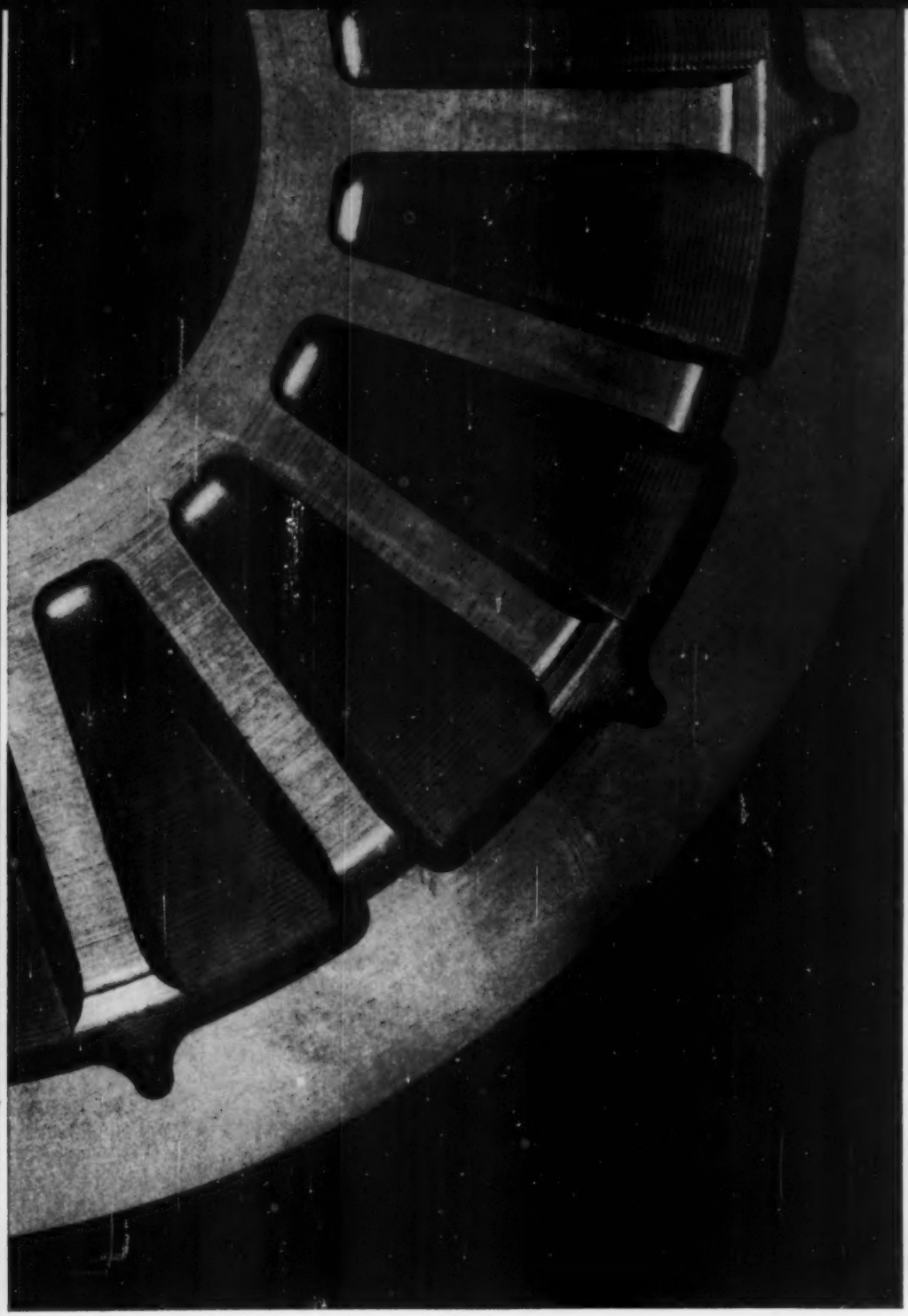


New IBM computer language...AUTOPROMT cuts milling time for this helicopter gearbox cover by 75%

AUTOPROMT (AUTOmatic PROgramming for Machine Tools) is a powerful new computer language designed to broaden the use of numerically-controlled machine tools.

AUTOPROMT, for the first time, lets an engineer *describe the surfaces* of the three-dimensional shape he wants milled, *rather than calculating every path* the tool must follow in order to machine the part.

AUTOPROMT leaves to the computer the task of automatically generating these tool paths. You describe the part to be milled and the tool to be used in simple, *English-like*



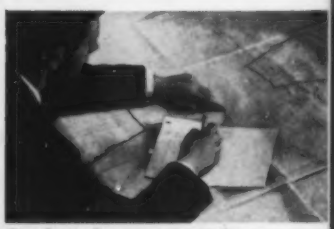
terms. The computer does the laborious calculating work.

AUTOPROMT produces results like these: the time to mill the gearbox shown in the photographs cut to *one-fourth* the machine time required by conventional methods. AUTOPROMT reduced the lead time from blueprint to production *from three months to two weeks.*

AUTOPROMT is available to IBM customers. Call your local IBM Representative for complete details on this latest advance in Numerical Control of machine tools.

IBM®
DATA PROCESSING

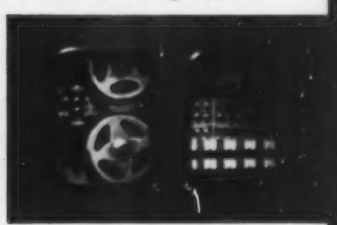
Here's the way AUTOPROMT works at United Aircraft Corporation



The Parts Programmer, using a conventional blueprint, prepares 180 one-line statements in AUTOPROMT language.

The statements are punched into standard IBM cards and entered into the IBM 7090 Data Processing System. (AUTOPROMT also works with the 704 and 709 Systems).

The 7090, programmed with AUTOPROMT, produces 8000 tool path instructions needed to direct the Pratt and Whitney Co. Inc. Numeric-Keller Continuous Path Milling Machine.



Punched tapes direct the Numeric-Keller Milling Machine.

The Numeric-Keller mills the helicopter gearbox cover.

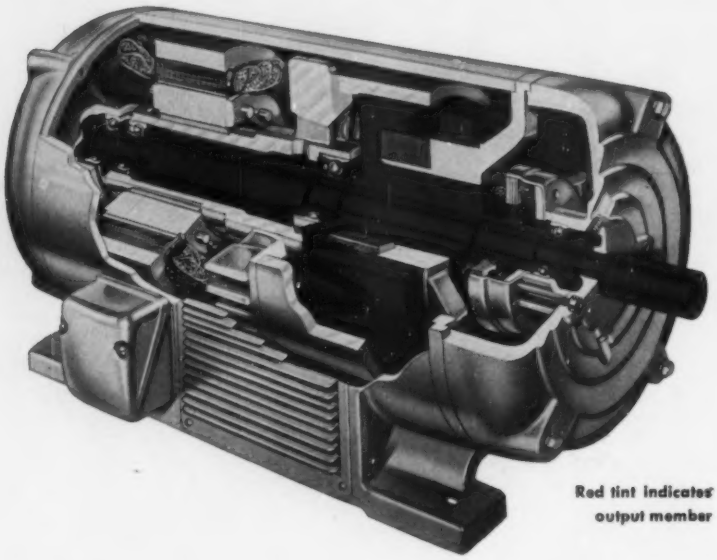
CIRCLE 59 ON READER SERVICE CARD 59

NOW— another FIRST by the Originator of Eddy-Current Equipment

NEW

DYNAMATIC®

Model 905 Ajusto-Spede® Drive



Red tint indicates output member

Extends Capacity Range to 15 HP in the Popular Quill-Type Design

The addition of the new model ACM-905 to the famous ACM-903 and ACM-904 lines of Dynamatic Ajusto-Spede Drives makes the desirable features of Dynamatic Quill-Type design available for many new applications.

Dynamatic Ajusto-Spede Drives provide controlled adjustable speed from an AC power source. Standard control features include on-off clutch control, infinite speed adjustment, constant speed regulation, and jogging. Any of a variety of special features may be easily and economically added to the standard control.

All Quill-Type models are available with either eddy-current, Dyna-torQ, or fail-safe brakes.

An Ajusto-Spede Drive, a control unit (either electron tube or transistorized magnetic amplifier), and a push-button station comprise a compact, easily installed, low-cost drive package.

Check these Ajusto-Spede® Advantages

- ★ Infinitely adjustable speed from AC power
- ★ Simplified construction
- ★ Compact design
- ★ Wide speed range
- ★ Remote control
- ★ Stationary field coils
- ★ Excellent performance characteristics

Send for Illustrated Descriptive Literature

EATON

DYNAMATIC DIVISION

MANUFACTURING COMPANY

3122 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

British Admiralty chart of New York harbor (1775) reproduced on Kodagraph Contact Film, Estar Base. Courtesy of New-York Historical Society.

Surest course to take in drawing reproduction!

Choose from Kodak's great new line—Kodagraph Reproduction Films, Estar Base

As a draftsman or engineer, there's a selfish reason for asking your reproduction department or local blueprinter to make your "second originals" on new Kodagraph *Estar Base* films: *You'll find them much easier to work with!*

In addition to being as durable and dimensionally stable as any film you can name, Estar Base prints have clean backgrounds, more contrasty images, *and a superior drafting surface on both sides.* You can draw with light strokes . . . use pencils with a wider range of hardnesses. And since there's less abrasive action, pencil points stay sharper longer. Also, detail stays put . . . is less inclined to smear, can be erased easily. See for yourself. Ask your reproduction department or local blueprinter for second originals on Kodagraph Estar Base film.

1. Kodagraph Autopositive Film, Estar Base. First choice for general reproduction work. Gives you same-size *positive* second originals *directly.* Excellent results obtained with print-through or reflex printing (even from metal templates). Can be exposed and processed in room light.

2. Kodagraph Contact Film, Estar Base. Ideal for making same-size reproductions from film or low-cost paper negatives of old or weak line drawings. Job's this easy: Expose in standard contact printers . . . process with paper or litho developers.

3. Kodagraph Projection Film, Estar Base. Welcome change-of-scale "specialist." This high-contrast, quick-processing film gives you sharp and clean results when enlarging microfilm negatives, or reducing large drawings, blueprints, maps. Can be handled with 1A (red) or OA (yellow) safelight.

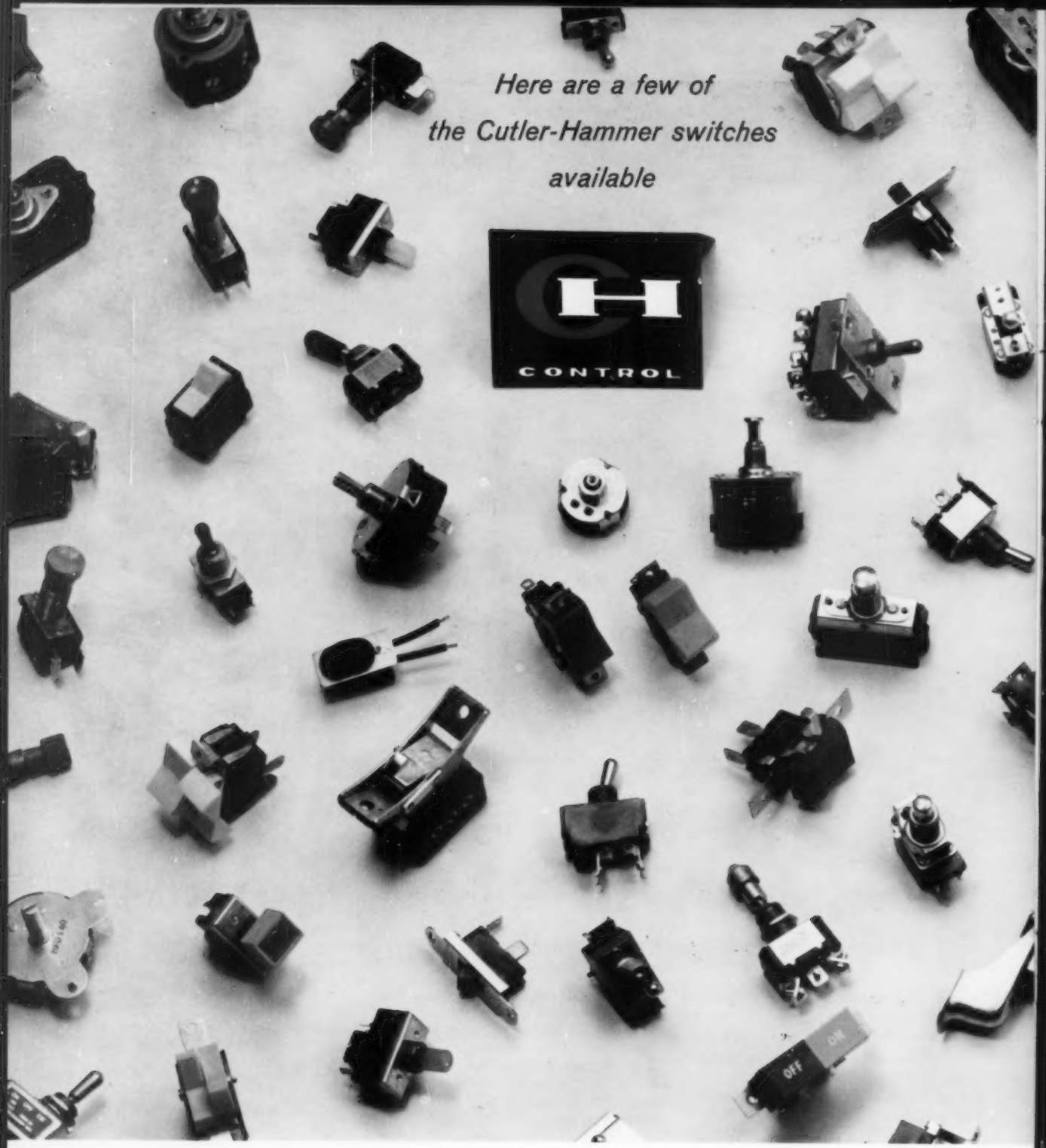
For further details, write to Eastman Kodak Company, Graphic Reproduction Division. Rochester 4, N.Y.

NEW!
Kodagraph

REPRODUCTION FILMS
for best line-for-line reproduction

CIRCLE 61 ON READER SERVICE CARD

CIRCLE 62 ON READER SERVICE CARD→



Why Cutler-Hammer helps design more switches into

Here are several reasons:

1 We build and design switches with a high degree of reliability (and offer exclusive features that mean better performance).

2 We maintain rigid quality control from assembly to delivery. Production switches are regularly taken off the line for live tests, to be sure of consistent high quality.

3 We have the broadest line available (those shown above are but a few examples of what we have developed).

4 We can design and build the special switch you need (if we don't already have it).

5 We offer prompt and efficient service, including new, really fast delivery to satisfy your emergency requirements.

A Cutler-Hammer sales engineer can be in your office in a matter of hours (you will find them in every major city) or write us at Cutler-Hammer, W-225, Milwaukee 1, Wis.

more products than any other switch manufacturer

WHAT'S NEW? ASK...

CUTLER-HAMMER

CONTROL

Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. • Associates: Cutler-Hammer Canada, Ltd.; Cutler-Hammer Mexicana, S. A.

News about R&A SINCE 1913 **Adhesives**

FOR ALL METALS AND ALL PLASTICS

Now you can "contact bond" polyethylene foam to itself, wood, metal, concrete...

8 typical Bondmaster® adhesives for flexible foams:

FOR POLYETHYLENE FOAMS

BONDMASTER G590: High strength "contact" type adhesive for **foamed** polyethylene to itself, to wood, metal, hardboard, etc. Good heat-resistance; excellent resistance to salt water and high humidity conditions.

BONDMASTER G523: "Longer-open-time" variation of BONDMASTER G590.

FOR CLOSED-CELL VINYL FOAMS

BONDMASTER G483-20: Widely specified for athletic protective equipment, gymnasium mats, etc; withstands standard vinyl protective coatings.

BONDMASTER R379-20: Highest strength, salt water, humidity and solvent resistance; withstands hot vinyl marine coating dips.

FOR POLYURETHANE & RUBBER LATEX FOAMS

BONDMASTER R275: Outstanding economy coupled with softest, dimple-free seams. For urethane and rubber latex foams to themselves or to each other.

BONDMASTER R322: R275 type in a non-flammable solvent. Soft seam, quick-grab, dries tack-free.

BONDMASTER R828: Highest strength bonds of polyurethane and vinyl foams to wood, metal, or other rigid surfaces, and to many fabrics.

BONDMASTER R203: Extremely fast drying for instantaneous bonding of fabric reinforcing tapes to polyurethane or latex foam cushions, etc.

WRITE FOR DETAILED TECHNICAL DATA

R&A SINCE 1913

RUBBER & ASBESTOS
CORPORATION
235 BELLEVILLE AVENUE
BLOOMFIELD, NEW JERSEY

That photo, above, shows a typical bonded mitred joint at the corner of a trampoline protective bumper. Not only are the polyethylene foam slabs bonded to each other, but the entire bumper is firmly anchored to a concrete apron . . . with the very same adhesive.

The completed bonds are subjected to all sorts of rigorous punishment in use (abrasion, impact, peel forces, etc.). In addition, since these are field installations, the assembly must withstand the broadest possible span of outdoor weathering conditions (sunlight, rain, sleet, snow, salt water, heat, cold, etc.).

Either of two high-strength, water-resistant R&A "contact bond" adhesives now make it possible for you to achieve bonds of foam-tearing strength between this expanded plastic and just about any other material.

BONDMASTER G590 is a fast-drying "contact" adhesive which can be applied by brush, trowel, paint roller, flow gun, or spray gun. At room temperature, adhesive-coated components can be mated in about 20 to 30 minutes after application. Assembly consists simply of aligning coated parts carefully before mating and then using firm hand pressure to insure intimate contact over the entire area being bonded. Bonds of foam-tearing strength develop instantly.

BONDMASTER G523-20 is a longer "open time" variation of this product for use where an extended delay between coating and assembly is desired.

WRITE FOR FREE DATA

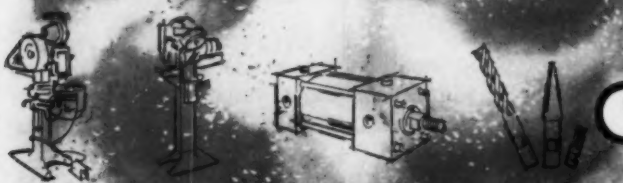
Write for Special Application Report on "Bonding Foamed Polyethylene", detailing application techniques for bonding this new foam with these formulations. If you will describe your problem in detail, we'll be glad to send a no-charge sample for evaluation.

Along with outer space . . .

the T-J Spacemaker is still making

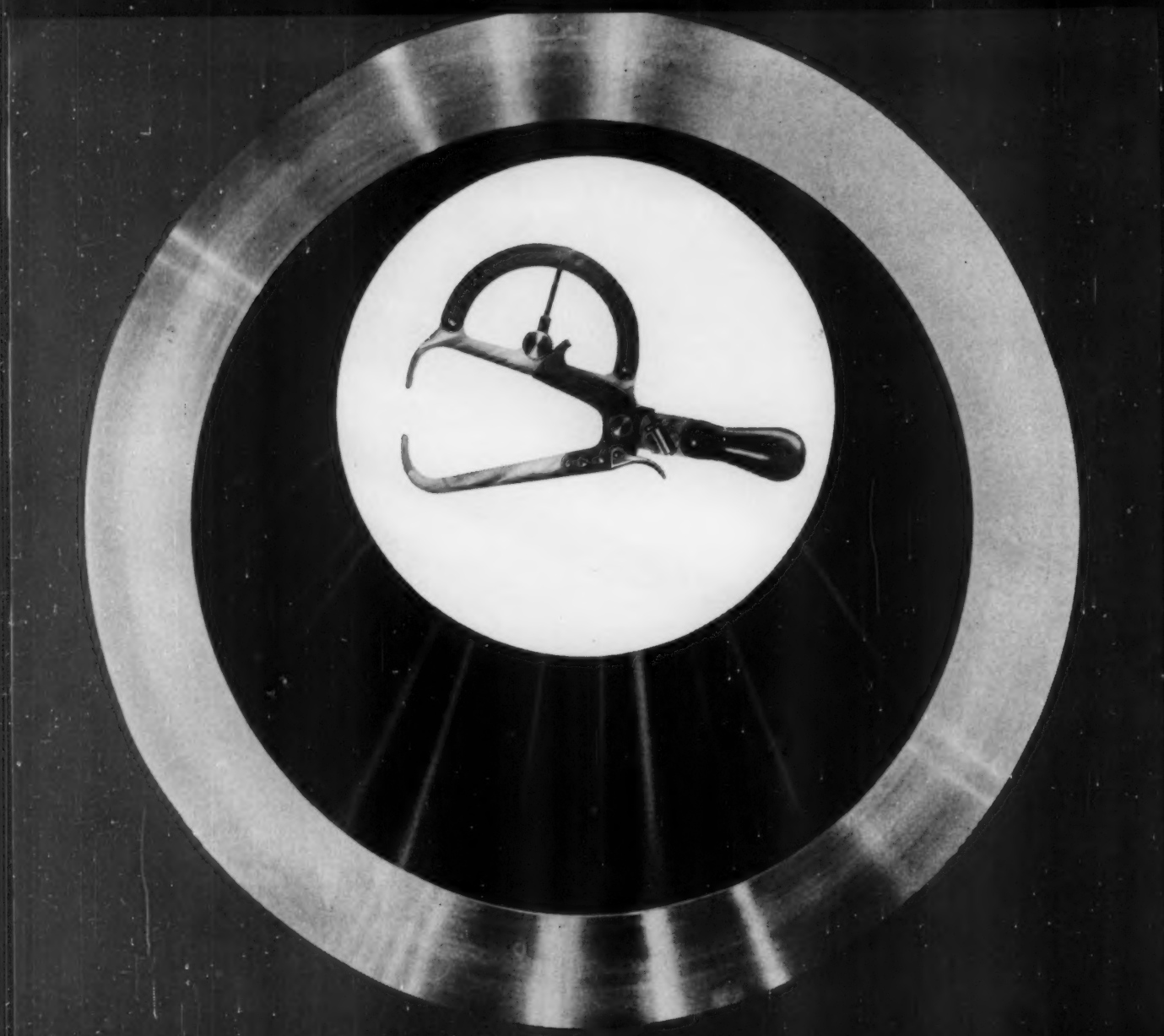
BIG NEWS

The T-J Spacemaker cylinder line is not now, nor ever has been, a probe into outer space. It is offered as a practically designed, research engineered and time tested product. Its Spacemaker feature (no tie-rods) and rugged construction gives greater strength, saves space and reduces costs in all power drive applications. The Spacemaker is available in a complete range of bore sizes and strokes, air or hydraulic, and contains many *plus features* and extras as STANDARD . . . NO EXTRA COST! Write Tomkins-Johnson, 2425 W. Michigan Ave., Jackson, Mich. for Bulletin #155-4 and for full particulars, today.



RIVITORS CLINCHORS CYLINDERS CUTTING TOOLS

T-J TOMKINS-JOHNSON
JACKSON MICHIGAN



NEW SIZE RANGE SURPRISE!

HERE'S A NEW PROCESS in centrifugally spun tubing that offers you greater freedom in design. It's ACIPCO CERAM-SPUN®... the new ceramic mold process* that is not limited by equipment sizes!

NOW, YOU CAN ORDER almost any combination of sizes you require. ACIPCO CERAM-SPUN® tubes offer O.D.'s from 2.25" to 50"; and wall thicknesses from .25" to 8". As-cast lengths are furnished from 4 feet to 20 feet, longer lengths are made by welding.

THINK OF HOW MUCH this process can save you! You'll avoid the cost of unnecessary metal waste, and excessive machining charges. And ACIPCO's complete "under one roof" operations — including heat treating, machining and welding — offer many additional economies. No need for the delays and excessive costs that often result in buying from multiple sources.

If you design, manufacture or use tubular component parts, it will certainly pay you to investigate the versatility of ACIPCO CERAM-SPUN® tubing and the flexibility of ACIPCO's integrated facilities. Contact **ACIPCO STEEL PRODUCTS,** Division of American Cast Iron Pipe Company, Birmingham 2, Alabama.

*Patent applied for

ACIPCO CERAM-SPUN®
STEEL TUBING

PRODUCT
ENGINEERING HORIZONS

AUGUST 7, 1961

THE NEW KING

In Genesis we read of Joseph, whose coat of many colors and whose dreams turned his brothers against him so they cast him into a desert pit. Medianites found him, sold him to an Ishmaelite caravan, which in turn sold him to an Egyptian officer. Joseph prospered and found favor with Pharaoh, so he became second in the kingdom. Thus he could save Jacob, his father, his twelve brothers and their families during the seven lean years of famine. And his relatives in turn prospered so they became the largest group in Egypt—the twelve tribes of Israel.

Then in Exodus (1:8) the tale of the tribulations of the Israelites (and of Egypt) begins with a single, vital sentence: "Now there arose up a new king over Egypt, which knew not Joseph."

There are still companies whose engineering knowledge and records are in the minds of individuals, who have failed to provide adequate facilities for information storage. This in face of the fact that the latest EJC survey shows that 8.6% of engineers change jobs each year. Or in face of our own circulation records, which show that better than 25% of our readers change job, title or home address annually. Where do the company standards and specialized bits of knowledge go then?

Or, again, there are the engineers who fall into the very human habit of depending on personal friendship—rather than ability or plain hard work—for security. They assume friendship with, or toadying to, the boss will guarantee their jobs. Then the boss dies, is retired, is transferred . . .

Or, yet again, there are the individuals and companies who rely on personal friendship with a "kingpin" to gain and hold acceptance of their designs—and sometimes to avoid the troubles of design modernization. But a king who loses his kingdom has little authority and less buying power . . .

There are, of course, endless cases in which somebody says confidently, "I already told Joe . . ." He forgets that "Joe" may not remember, may have moved, may not want to remember, so the vital facts are not where they're needed at the required time.

We could go on quoting examples, but the point is simple: **Every day there are arising new kings who may not know Joseph—or you.**

R. Langeman

←CIRCLE 66 ON READER SERVICE CARD

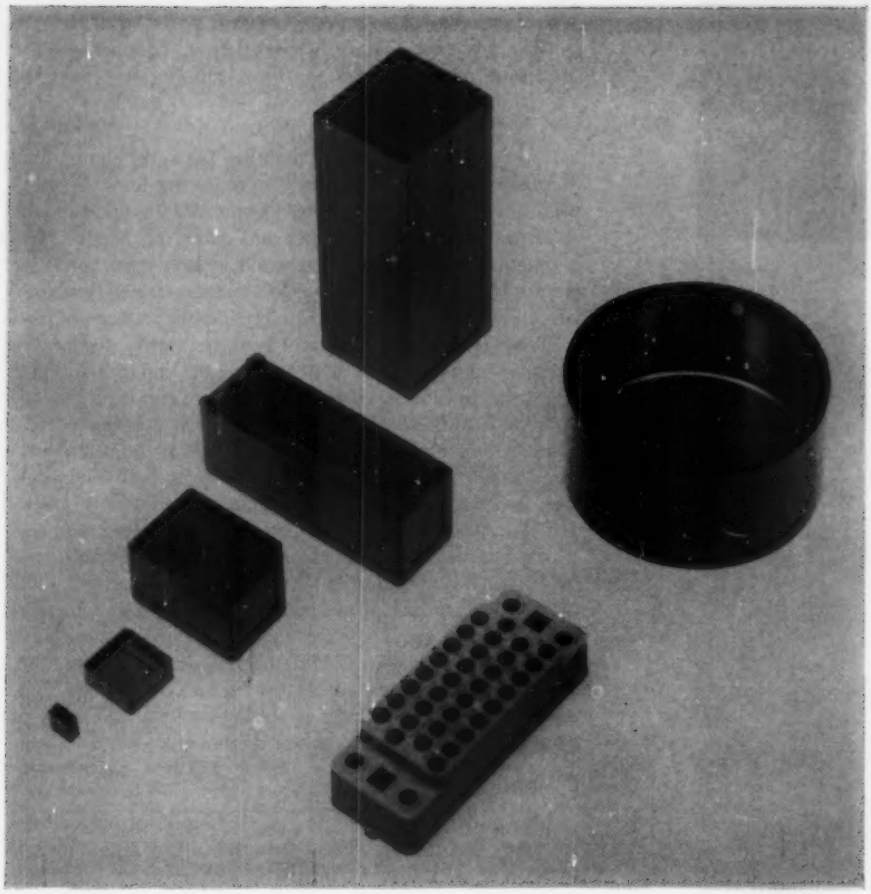
CYCOLAC® BRAND

TOUGH, HARD, RIGID POLYMERS FROM BORG-WARNER

The Starlite®. . . newest of the compact telephones. Styled in white and five decorator pastels to please milady. Miniaturized and produced by Automatic Electric Company for independent telephone companies . . . the Starlite employs CYCOLAC brand ABS polymers for both the body and the handset housing. This versatile ABS material gives the Starlite telephone shatter-proof protection against impact; optimum resistance against stain bleed-in from lipstick, nicotine and hand creams. The molded CYCOLAC surface is gleaming smooth, warm to the touch, yet is rigid and strong enough to withstand the roughest handling. This Borg-Warner material is the tough, hard, rigid plastic that is setting new standards through-out the plastics industry. For additional data—write Department **S-8.**

CYCOLAC . . . *better in more ways than any other plastic*

MARBON CHEMICAL DIVISION **BORG-WARNER**
WASHINGTON WEST VIRGINIA



Strong, thin sections are possible when parts are molded from epoxy resin. The materials are more fluid than other thermosets and will fill narrow mold crevices.

MOLDED EPOXY PARTS

For thin walls plus heat resistance

Do your parts need better heat resistance? Or higher strength? Or more complex shape? You can have all three if you choose one of the molding epoxies. Although formulations are still high priced because they are relatively new, these resins are becoming more competitive with other thermosets.

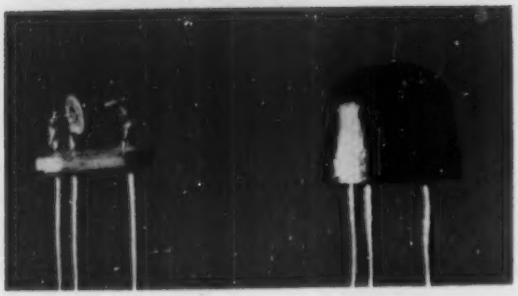
JOHN KIRSNERS, *chief engineer, Epoxy Products Inc.*

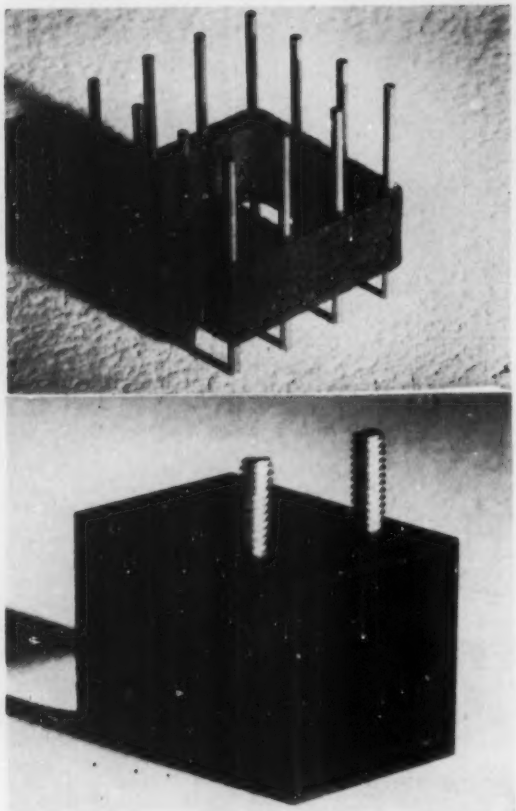
■ Molded parts of epoxy resins have high strength, heat resistance and good electrical properties. Sound walls as thin at 0.008 in. are practical because epoxy resins will flow into thin mold sections. And their high strength can compensate for the reduced wall thickness. Epoxies retain their strength at higher temperatures too. They can be used continuously at 400 F. Thin epoxy shells resist penetration by moisture. Their permeability is lower than that of other plastics and competes in applications formerly limited to glass-to-metal assemblies.

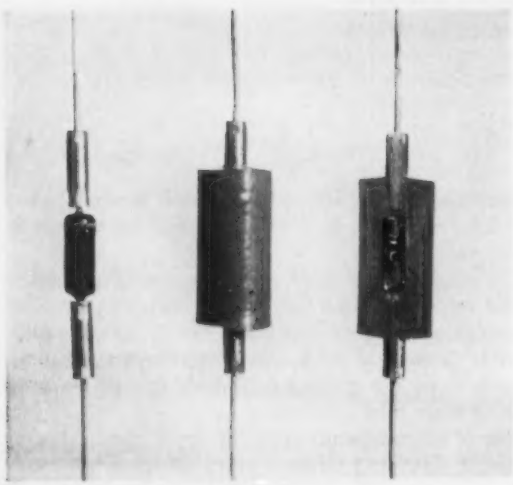
Molded epoxy parts are much like their cast counterparts. Both have similar compositions: They are formed by a mixture of 2 ingredients—a resin and a hardener or catalyst to cure the resin.

But molded versions have a wider range of properties than cast versions because they tolerate higher proportions of filler without losing molding properties. Even when filler content is as high as 70%, molding compounds under pressure will fill the molds easily while casting becomes difficult at these filler contents.

Choice of fillers depends upon the application. Mineral fillers (mica, slate, and silica) improve electrical properties







at elevated temperatures. Fibrous fillers (asbestos and glass) improve strength, but are usually not satisfactory for critical electrical purposes because they act as wicks for moisture. Metal powders increase thermal conductivity for fast curing and improve dimensional stability after molding.

Low molding pressures

Epoxy resins need lower molding pressures than other thermosetting plastics because the resins are fluid. Typical pressures are as low as 100 psi, compared to the 1500 to 3000 psi needed for phenolics and diallyl phthalates. Experimental formulations that mold at still lower pressure (about 10 psi) have been used to simultaneously encapsulate and mold delicate electronic components.

However, some pressure and heat are always needed for molding epoxies. If parts are so fragile that temperature must remain below 300 F or no pressure can be tolerated, molding cannot be used; a casting resin is a better choice. These will cast without pressure and cure at room temperature though parts will have poorer dimensional tolerances, and slow production. Also, minimum wall thickness is from $\frac{1}{4}$ to $\frac{3}{8}$ in. depending on the resin and casting method.

Molded parts do not necessarily complete their cure in the mold and may still be rubbery when ejected. Thus unless they are held in shape while cooling they will tend to distort. In general, large parts, particularly those with thin walls, will distort more than small ones. For example, a thin-walled cylinder will distort into an oval. For a 2-in. diameter, out-of-roundness is about $\frac{1}{16}$ in.—a difference of $\frac{1}{8}$ in. between major and minor diameters.

Designing the Part

More draft is required for parts molded of epoxy than for parts molded of other thermosetting plastics. This is because epoxies are good adhesives and have low shrinkage. Even when the mold surfaces are polished and chrome plated and a parting agent is mixed into the molding powder, large drafts plus ejection pins are needed to facilitate part removal. Thicker sections or ribs must then be designed in to stiffen the part against ejection forces and to provide bearing points for the pins. Minimum draft is about $\frac{1}{4}$ deg per side for parts with a draw length up to $\frac{1}{4}$ in. Parts up to 2 in. or those with thin walls will require larger drafts to $1\frac{1}{2}$ to 2 deg.

Best dimensional tolerance is ± 0.001 in. for dimensions up to 1 in. and ± 0.004 in. for parts 4 in. in length. In general, the best tolerances can be expected from parts designed for minimum shrinkage. These steps will help:

1. Choose one of the short-flow formulations—these are more dimensionally stable.

2. Complete cure in the mold—fully cured parts will not shrink further during storage.

1 Molded cap protects and pots this transistor. Because the epoxy resins flow at low temperatures and pressures, electronic components like this one can be molded in place.

2 Metal inserts are securely held by adhesive power of epoxy resins. After molding, the dimensionally stable plastic does not shrink away from the insert.

3 Molded body incorporates two terminals and a diode into a single unit. The terminals, which fit into spring clips, make the soldered diode easy to replace.

COMPARISON OF EPOXIES WITH OTHER THERMOSETTING MOLDING COMPOUNDS (as required by Mil-M-14E)

Property	Conditioning	Epoxy	Phenolic MFE	Melamine MME	Silicone MSG	Alkyd MAG	Diallyl-Phthalate
Compressive strength (psi, min avg)	73F 50%RH	22,800	15,000	25,000	15,000	15,000	18,000
Flexural strength (psi, min avg)	73F 50%RH	10,900	8000	6000	6000	7500	6800
Tensile strength (psi, min avg)	73F 50%RH	5600	4200	4200	2500	3500	4000
Dielectric strength 50%RH	73F						
short-time		400	325	325	325	150	325
step-by-step (v/mil, min avg)		375	275	275	300	125	275
Volume resistance (megohm, min)	158F 100%RH	2.000	2.0	.....	1000	.....	2.0
Surface resistance (megohm, min)	158F 100%RH	2.000	5.0	.....	1000	.....	5.0
Heat distortion (°F, min avg)	....	293	239	248	392	347	300
Water absorption (%, max avg)	48 hours at 122F	0.05	0.10	0.50	0.50	0.50	0.70

3. Keep sections in molded parts thin, so over-all shrinkage will be less.

Sharp corners can be molded. Epoxies have better flowing characteristics and they are tougher than other thermosetting plastics (tensile elongation is as high as 22%). Other plastics require generous fillets and radii at corners.

Metal inserts are readily bonded into the molded part because of the adhesive characteristics mentioned above. Further, the epoxies do not shrink in contrast with other thermosetting materials such as melamines that shrink after molding and permit metal inserts to loosen. Diallyl phthalates have better dimensional stability than melamines but do not match adhesive properties of epoxies.

Threads are difficult to mold into epoxy parts. A better method is to mold threaded studs in the part. The same adhesion which makes threads difficult to mold will assure tight adherance of the threaded inserts. Threaded studs are preferred to hollow inserts with female threads. These are difficult to clean after the part is molded.

CAST VS MOLDED EPOXIES

Resin formulations for casting are better known because they were developed earlier. These formulations are simple. Two components—resin and hardener—are mixed just before casting and then poured into the mold cavity.

Molding resins took more time to develop. Here the two components are premixed in a single power so the hardener must remain inert until activated by molding heat.

Curing speed, and therefore production rate, depend on activity of the hardener. If the hardener is arrested in a partially reacted state, it is called a B-stage system. It cures rapidly during molding. If the hardener is completely inert and does not react until heated, it is called a latent hardener. It is more stable and has longer shelf life.

For molding, compounds are generally described by their flowing characteristics. A long-flow material with low viscosity requires little pressure to fill thin sections. Short-flow powders with high viscosity require higher molding pressures. They also shrink less and can be molded to better tolerances.

Normally fillers are added for strength or electrical properties. They also reduce amount of resin needed to make the part. Because epoxies are not cheap (about 60¢/lb) it is tempting to stretch the resin by adding more filler. But this has practical limits—higher filler content decreases fluidity of the resin and beyond certain limits prevents filling of the mold cavity.

Oil-absorbant fillers, like mica, absorb the resin and increase viscosity rapidly. They are limited to about 35% in cast mixtures and about 50% in molded epoxies. Non-absorbant fillers, like slate or metal powders, can be added in higher proportions.

EDITOR'S NOTE: Recent articles on load carrying plastics and how to design and fabricate with them:

Fiberglass-reinforced Thermoplastics, May 15 '61, p 95—As with the thermosets, the technique of fiber reinforcement creates entirely new materials. These close the gap between the thermoplastics and the thermosetting materials.

Design Polycarbonate Parts This Way, May 1 '61, p 46—How to make the most of polycarbonate resins' properties while minimizing costs of finished parts.

Designing High-impact Phenolic Molded Parts, Mar 7 '60, p 54—Reinforcement makes conventional phenolics a strong competitor to metal where shock loads are a problem. Article gives proper design criteria to use.

Which Process for Fibeglass-reinforced Plastic Molded Parts, Jan 11 '60, p 47—Up-to-date guidance on the 7 key processes for glass-reinforced plastics.

—Herbert Kee

If it moves, it vibrates—
and vibration is one of the most
persistent causes of product failure.
Whether your product is a washing
machine or a satellite, these six
steps will guide design (or redesign)
effort . . .

WHEN VIBRATION THREATENS YOUR PRODUCT

PHILIP T PACKARD, *chief mechanical engineer*
Military Products Div
General Dynamics/Electronics

■ Of all the environmental enemies, vibration is perhaps the most damaging, and the most difficult to avoid. By comparison, the effects of temperature, corrosive and abrasive atmospheres, atmospheric pressure and humidity are relatively easy to handle. But vibration can have unexpected effects on even the most robust elements of your design–structural parts fail in fatigue, screws shake loose, soldered connections break, sensitive electronic components fail to function. It can literally shake a product to death.

The cure is a thorough program of analysis and test. I have divided it into six steps. To be successful, the program demands some of the most powerful mathematical tools available to the engineer plus a variety of reliable, accurate (and frequently expensive) vibration-testing equipment. Designing "vibration proof" equipment can be tedious and time consuming. But attacked systematically, it should yield a product in which the hazard of vibration failure has been reduced to a minimum.

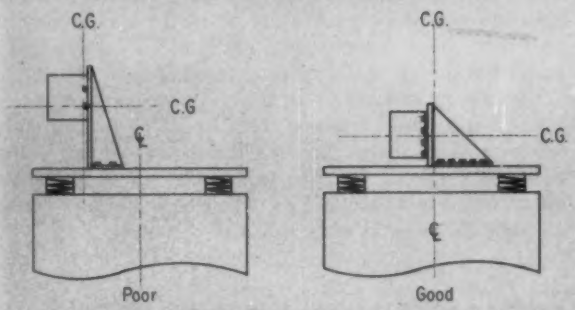
Regardless of whether it's a new design or a redesign, a consumer product or a missile, the requirement for vibration resistance exists whenever there is a source of potentially damaging vibration. At this point, you have three choices: You can either isolate the source, isolate the sensitive elements, or reinforce sensitive elements to withstand damaging environment. In most cases–the most difficult ones–you will be limited to the second or third alternative, or both. In either event, you are committed to a rigorous design and test program which begins with. . .

Step I–Design analysis

Finding which elements of the design are most vulnerable to vibration and what design changes will be most effective is not a simple matter. Whether a thorough analysis is justified depends on the product; if the cost of fabricating it is high, or if extreme reliability is required, it may be more expedient to make a part-by-part analysis on paper before testing. But if the device is simple enough that several designs can be made and tested, or if it has so many elements that a complete paper analysis would be more costly than an equivalent test program, a partial analysis may be sufficient.

The simplest way of making a vibration analysis is to determine the natural frequencies of individual structural members. Adjust these resonances so that they fall outside the forcing frequency. To carry the analysis a step further, consider the equipment as a whole, treating it as a series

THESE RECOMMENDATIONS FOR BETTER MOUNTING FIXTURES



1. Select a lightweight material.
2. Provide for vibration on all axes.
3. Avoid resonance in test range.
4. Mount equipment in center of fixture.
5. Maintain lowest possible center of gravity.
6. Center fixture on vibration table.
7. Secure the equipment with all mounting screws.
8. Provide sufficient fixture mounting screws.

of interconnected plates and beams. The more detailed the analysis, the more complicated the mathematics will be. Simple designs and partial analysis of more complex ones can be handled with the fundamental formulas shown in the box on this page. A detailed analysis requires advanced mathematical techniques and in many cases, computers are used to reduce the effort.

The analysis will indicate what reinforcements are needed in an existing design and what form a new design should take. In some cases, the solution may be a vibration absorber or isolator. The analysis also serves as a record for future analysis and as a guide to testing the first design.

Step II—Requirements of the test

For military equipment, frequency, amplitude, and time duration of vibration are set by the applicable military specification. Because of the high frequency vibrations radiated by jet and rocket engines and because there is little opportunity for effective damping in aircraft, these are perhaps the most punishing service conditions a designer faces. New requirements for missiles specify that equipment shall also withstand vibration from certain levels of acoustic radiation.

In non-military products, where test levels are seldom specified, vibration requirements are set by making measurements of the actual environments. Normally, these specifications will not be as severe as those for military products. Typical inexpensive measuring instruments are:

- Stroboscopes—These show frequency and amplitude of a variety of motions.
- Tachometers—They reveal fundamental frequency of rotating machinery.
- Peak-reading accelerometers—For measuring maximum vibratory acceleration of concealed parts that cannot be monitored directly. They also record mishandling shocks such as a drop from a bench.
- Strain gages—They indicate vibratory stress at critical points of structural members.
- Transducers and strip-chart recorders—These give an accurate analysis of frequencies and amplitudes, but they are more expensive and should be used only when other methods are not satisfactory.

Duration of the test and the number of axes to be tested will be dictated by these environmental measurements.

The most damaging frequencies for mechanical equipment are encountered in low ranges where amplitudes are large. High frequencies having an equivalent energy level can cause resonance in smaller components such as vacuum tubes, relays, and hydraulic control components. Large structural members absorb this high frequency energy and because associated amplitudes are small, they can survive without fatigue damage.

Step III—Choice and design of test equipment

Choice of the vibration table depends on the size and weight of the item to be tested. Table capacities cover a wide range from 100-, 300-, and 500-lb ratings to special capacities over 1000 lb. Most tests can be handled by tables in the 100- to 500-lb range.

There are two common types of tables. For low frequencies (about 70 cps, max) a mechanically driven table having a variable-throw crank shaft or a variable-offset weight is usually adequate. For frequencies up to 3000 cps (and beyond, in some machines) an electromagnetic vibration platform is needed. They are more versatile than the mechanical tables and usually have a feedback control, which varies the amplitude with changes in frequency to give constant acceleration over the test band.

The means of coupling the table to the load is another part of the test equipment and one that is frequently overlooked because of its apparent simplicity. Resonances in poorly designed mounting fixtures have been responsible for many unfortunate and unnecessary equipment failures. Ideally, the form of the fixture should approach a solid mass or block designed as an integral part of the table. Aluminum and magnesium are the best fixture materials

SOME TYPICAL FORMULAS FOR VIBRATION ANALYSIS

Vibration analysis begins with the familiar equation for resonant frequency of any undamped system

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

where k is the spring constant and m is the mass. The equation can be applied to any structural element. It is only necessary to substitute the values of k and m that apply to the particular structural shape.

For example, the formula for the fundamental frequency of an undamped cantilever is

$$f = \frac{1}{2\pi}\sqrt{\frac{3EIg}{WL^3}}$$

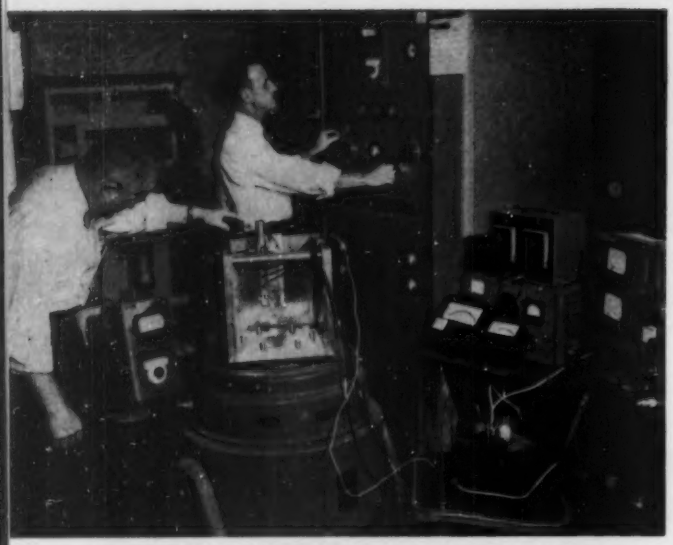
where E is modulus of elasticity, I is moment of inertia of the beam's cross-section, g is gravitational constant and W is the weight assumed to be concentrated at a point L inches from the base of the beam.

For a rectangular plate, simply supported on all sides, the formula is

$$f = \frac{C}{p}\sqrt{\frac{EQ}{P}}$$

Where Q is the stiffness factor $t^3/(1-\mu^2)$, with thickness t and Poisson's ratio μ), P is weight factor (weight per sq in. of surface), l is length of a side and C is a constant depending on the ratio of length to width (when ratio is 1.0, C = 17.85).

Though equations of this kind include a number of simplifying assumptions, they are sufficiently accurate to be useful in the analysis of most actual structures. More complex equations will be needed for unusually shaped structures or those in which there is a significant deviation from the simplified form assumed by the equation.



VARIETY OF INSTRUMENTATION is needed for accurate test results. Shown here is a portable amplitude probe (held by the man at left) and its meter, and an accelerometer pickup (mounted on upper lip of fixture) and its amplifier and meters (lower right). The component being tested is a variable RF attenuator. The fixture was designed to test both the attenuator and the complete attenuator assembly, which explains why it appears unnecessarily sturdy. In the background is the vibration table control console.

because their weight is not likely to overload the table, which could cause subtle changes in its output characteristic. Steel fixtures should be limited to tests of single components and small assemblies.

More complex fixtures are needed when the equipment is to be tested in more than one plane. To keep resonances in these fixtures from interfering with the test, avoid designs with cantilever beams, weights with flimsy supports, too much flexibility in supports, weak fasteners, poor welds. And before testing the equipment, check the fixture for resonances in the frequency range of the test. This check must be made with the equipment mounted on the fixture, or, if this is not possible, with a dummy load in place of the equipment. As far as is possible, dummy load should have the same weight, center of gravity and radius of gyration of the equipment.

Besides the test equipment, instruments will be needed to monitor test results. Most common is a peak-reading accelerometer attached to critical components or sensitive sections of the structure. For a thorough test, the full range of instruments will be used including a stroboscope, strain gages, transducers, and an oscilloscope with a fixed-frame camera. A high-speed camera will also be helpful in recording motion of the equipment and pinpointing weaknesses that cannot otherwise be seen or recorded. And, although the table probably includes built-in amplitude and frequency meters, it is generally advisable to supplement these readings with an accelerometer mounted on the table or a portable vibration amplitude probe.

Step IV—Test preparation

Test results will not be useful unless the equipment to be tested is in the same condition as it will be when installed. Tighten all mounting screws, latching devices, hold-downs and structural tie points to specified torques. Be sure that the equipment is firmly secured to its fixture and that accelerometers are mounted firmly to critical points on the structure. Do not remove covers or access plates to observe motion inside the equipment. This will change resonant frequency and reduce structural rigidity. Without these precautions, acceptable equipment may be judged unacceptable by the test—or may even be destroyed.

Step V—Test preparation

Before starting the actual test, sweep the entire frequency range keeping close watch on frequency and amplitude to check for damaging resonances. At the same time, you can also check accelerometer readings and other instruments to ensure that they are functioning properly. Notice particularly whether weight of the equipment has an effect on table output.

If there are no damaging resonances, the usual procedure is to sweep the frequency range indicated by the test specifications making note of the resonant points. Now hold the frequency at each of the resonances in turn for a length of time dictated by the test specifications—say, 15 minutes. Generally, a simple sinusoidal motion will be used. In the case of tests for missile equipment, however, the military is now requiring random-wave tests or mixed-frequency tests. These tests are expensive and difficult. Moreover, sine-wave tests are adequate for all military and commercial equipment except for that to be used in space vehicles.

Repeat the same test procedure for each of the axes to be tested. Whether the most vulnerable axis is tested first or last is a matter of choice.

When the test is completed, check the test specimen to see that it is functioning properly. Make a visual inspection of structural parts to ensure that there have been no failures that would not be evident during normal operation. Record all the data noting any particular facts that will help to interpret the results.

Step VI—Analysis and redesign

If the original design analysis was done carefully, the test should prove that the equipment will successfully withstand the vibratory environment. But there are flaws in even the best plans and the test results will probably indicate a need for some redesign.

The fault may be a purchased component whose design cannot be changed. In this case vibration transmitted to the component can be reduced by providing vibration isolators. Another way is to stiffen the mounting area to change the resonant frequency. Failure of a structural member can be remedied either by changing its resonant frequency or by providing damping elements. For damping, consider the use of riveted joints, flexural mounts, and external energy absorbers such as torsion rods or hydraulic cylinders. Magnesium and sandwich materials such as honeycomb also provide damping by converting a portion of the mechanical energy into heat.

If the product is redesigned, it should be tested again to ensure that the fault has been corrected and no other faults have appeared. Once it is in production, make periodic checks of production units. These tests can be

a go/no-go variety with provision for further analysis if rejection rate becomes excessive.

The cost of vibration qualification is not high but it does represent a modest portion of the design cost. In some cases the cost of testing may be greater than the cost of not satisfying the design goal. But for most products, vibration testing is easily justified. Design of a simple fixture and performance of the test seldom takes more than a few days for moderately complex gear. And for commercial products, where exposure to vibration is limited to low frequencies and moderate amplitude, the time and expense are even less. Redesign is expensive, particularly if it also includes redesign of production tooling.

EDITOR'S NOTE: For more about the tools and techniques of vibration testing, see:

Resonance-free Data from your Transducer, Feb 20 '61, p 72—How to spot and correct for undesirable resonances in transducer mountings.

How Good are Random-wave Vibration Tests?, Dec 5 '60, p 82—For most purposes, not much better than sine-wave tests, according to this author.

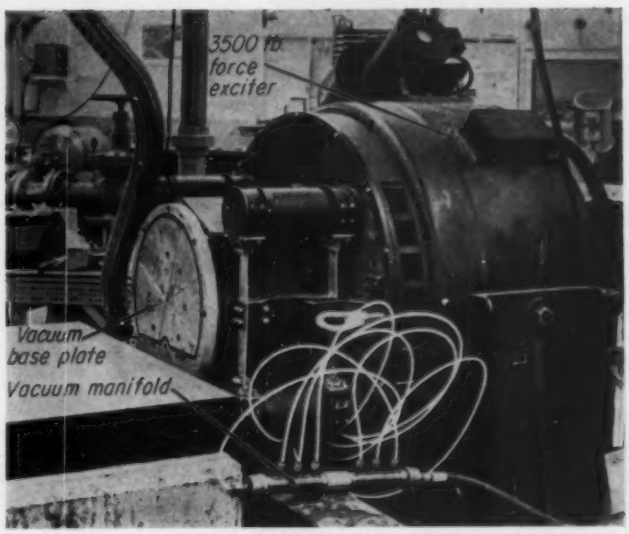
High-speed Photography Solves Design Problems, Aug 22 '60, p 29—High-speed motion picture cameras will solve design problems faster than analytical or mathematical methods.

For Rough Handling—These Shock Tests, May 11 '59, p 72—A discussion of two simple methods for test-dropping a product; with curves, equations and sample problems.

VACUUM HOLDS FIXTURES TO VIBRATION TABLE

Like a big suction cup, this special head on a conventional shaker table holds fixtures without bolts or clamps, saving hours of mounting time in production vibration tests.

C J McKENZIE,
Instrumentation Engineering
AiResearch Manufacturing Co of Arizona, div of The Garrett Corp



VACUUM HEAD on the business end of this vibration table permits rapid setup for production vibration tests. Except for this modification, the table is a conventional 3500 lb-force exciter manufactured by M B Electronics.

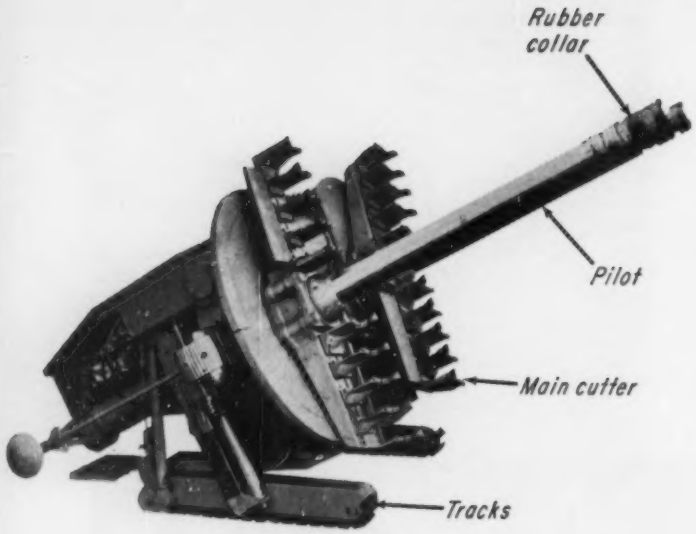
■ The purpose of the special vacuum head on the shaker table at right is to provide a quick-release coupling between the test fixture and the machine. This simplifies production vibration tests that require individual certification of several hundred identical items. We use two identical mounting fixtures—one is in use on the machine while the other is being prepared for the next test. This way, down-time between runs is reduced to a minimum.

In our case, the test items are different kinds of pneumatic valves manufactured by AiResearch varying in weight from 5 to 25 lbs and with a maximum volume of about 0.5 cu ft. However, the system could be used for testing production quantities of any component having fixed size and weight. The maximum allowable weight depends on the surface area of the vacuum head and the driving force. If the weight is too high or the force too great, there will be imperfect transmission of motion from the machine to the fixture or, in the extreme case, the seal will not hold. Our mount system is capable of operating effectively to 10 g at 2000 cps.

The special mounts have been fitted to two of our vibration exciters: a 12,000-lb-force exciter-used primarily for vertical testing, and a 3500-lb-force unit equipped for horizontal or "slippery table" testing. For vertical tests the exciter uses a circular 26-in. dia aluminum plate, 1½ in. thick, bolted to the exciter head. Machined grooves, radiating from the vacuum connection in the center of the plate ensure an evenly distributed vacuum. An O-ring seal at the outer rim of the plate and rubber gaskets around the counterbored mounting holes provide the seal. The fixture holding the valve to be tested is bolted to an aluminum plate of the same size.

A similar arrangement is used for the slippery table machine. Here the vacuum mount offers another advantage: it eliminates the tedious job of aligning the fixture with the table surface. The fixture in this case is a rectangular, cast magnesium block designed to permit testing in all three planes. With the vacuum head, testing time per plane of vibration has been cut by three to four hours.

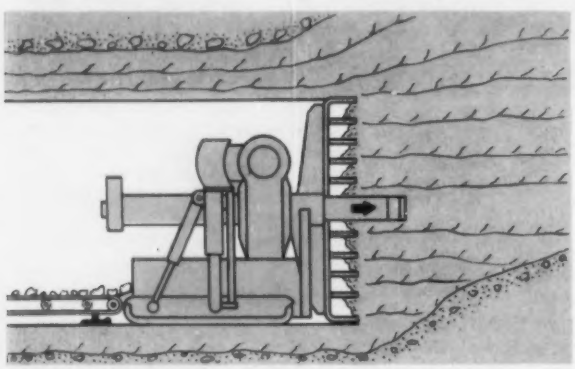
The vacuum connection on the head is coupled through a manifold to a vacuum pump with a free-air capacity of 57 liters and an ultimate pressure of 0.1 microns of mercury. A 1½-cu ft surge chamber between the manifold and the pump eliminates pressure pulsations. Experiments show that a negative pressure of 12 to 14 psi at the head is sufficient to hold the fixture firmly to the 12,000 lb-force exciter. Under these conditions, transmissability is unity in most cases. The interposed vacuum chamber does not affect the motion of the fixture. In fact, it has a cushioning effect, eliminating variations in phase and amplitude at various points on the head, sometimes found in bolted fixtures. ■

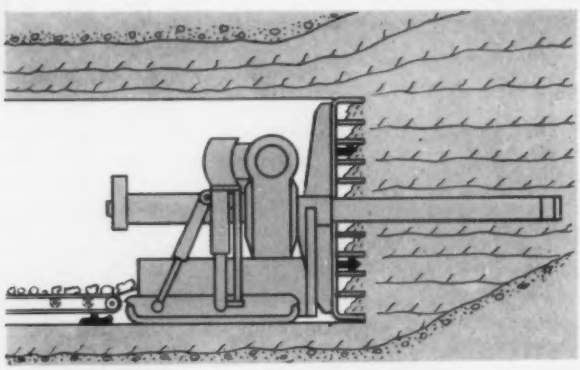


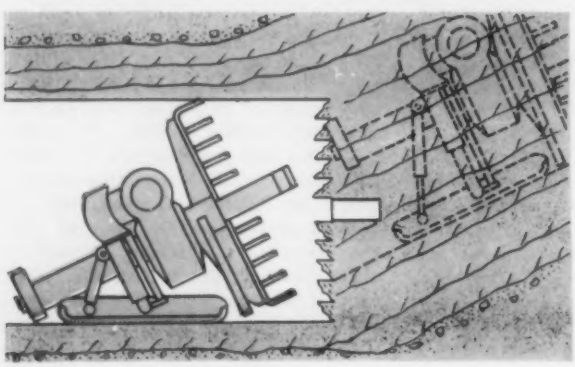
Bootstrap miner reaches for its own anchor

PILOT ANCHORS replace the bracing or dead weight usually required to resist cutter feed pressure. The pilot cutter, on the end of the hollow pilot bar, is rotated at 200 rpm while advancing into the coal face. At the end of the 5-ft stroke the pilot anchor, a rubber collar, is expanded hydraulically to lock the pilot in the hole. This provides a solid anchor which is used to pull the main cutters against the coal face. Collar area can be varied to suit the material being cut and other types of anchorage can be used. The technique has been successful even in such soft materials as mudrock.

Lightweight boring machine pulls itself into the material being mined. Pilot-pull anchor produces feed pressures eight times the machine weight without backup bracing.

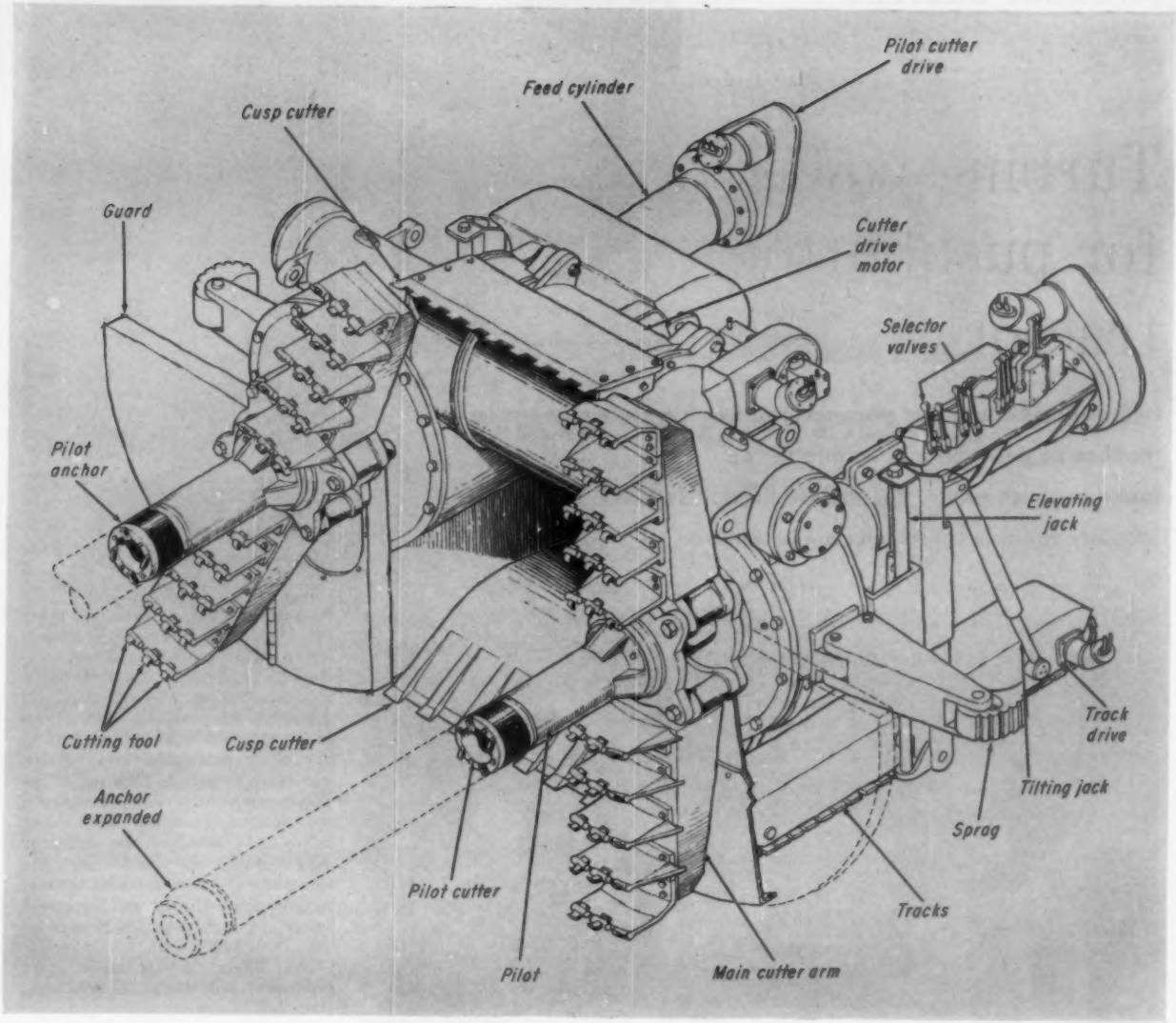






MINING CYCLE is accomplished by: boring pilots to 5-ft, stroke depth, locking in bore and, with main cutters rotating, advancing miner depth of feed stroke. Miner is held in main bore by automatic sprags extended against the wall of the main bore while pilots are boring.

The miner is realigned or turned in the bore by releasing the sprags and retracting the main cutters from the face, reapplying the sprags, unlocking and withdrawing the pilot cutters from their bores. The miner may then be turned and pilot bores started in the new direction. Length of the miner allows it to turn in the width of its own bore. Track adjustment permits changing vertical alignment upward 30° max and downward 15° max.



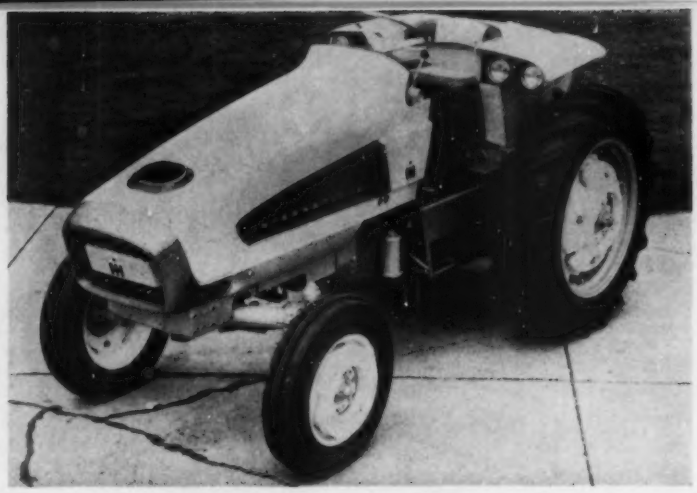
THE MINER is composed of two small-diameter rotary pilot cutters operating through the hubs of two large counter-rotating main cutters. The main cutters are supported in the body of the miner. The pilot cutters are mounted on the ends of hollow piston rods and are equipped with a mechanism to expand and grip against the bore. The material removed by the pilot cutters passes through the hollow piston rod and drive tubes and is discharged at the rear of the miner. The main cutters are guided on the pilots and pulled into the material by the action of hydraulic cylinders pulling against the anchored pilot cutters.

Main cutters cut intersecting circular bores leaving a cusp top and bottom. The upper cusp is cut by a fixed cusp cutter. The lower cusp may be removed at any height by the lower cusp cutter which is equipped with an electric impact vibrator. The lower cusp cutter is contained in a chute which will deliver cut material to a following conveyor or loader.

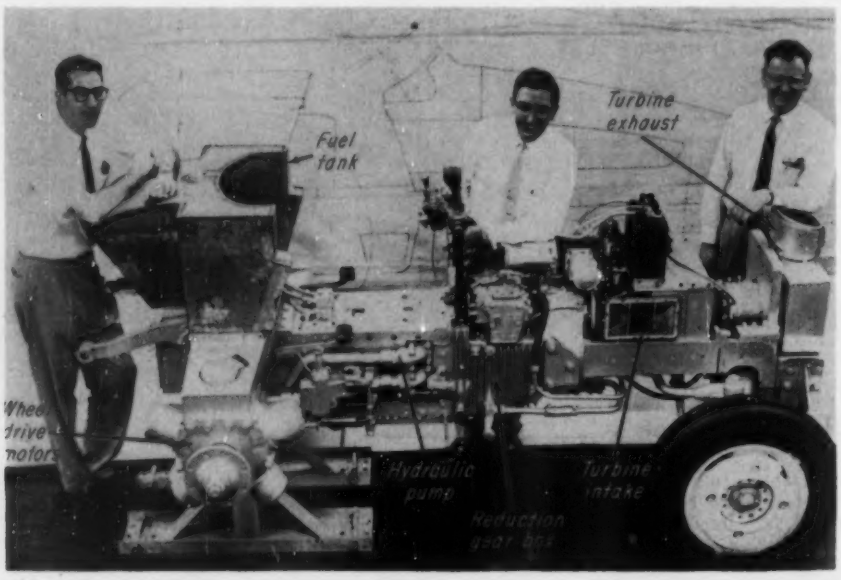
Drive for the main cutters is mechanically transmitted from the electric motor through a two-speed planetary transmission to worm-gear reducers on the cutter hubs. The pilot cutters, feed cylinders, and tracks are driven hydraulically from pumps powered by the electric motor and are controlled by spring-loaded hand valves. Separate hydraulic circuits for each side of the machine allows the operator complete control of feed and track speeds and pressures.

PS . . . The patented miner delivers 15 tons of subbituminous coal per minute to a conveyor system. In operation the miner cuts a smooth bore 7 ft high and 12.5 ft wide while advancing 3 to 5 ft/min. Electric powered machine uses a 200-hp liquid-cooled explosionproof motor to drive the main cutter at 30 rpm. Hydraulic motors are used for the pilot cutter and track drives. In addition to coal mining the pilot-pull principle is being applied to hard rock work, concrete and oil-well drilling. Concrete drill can cut 14 in. circles using a ¾-1 in. die. pilot hole 1 in. deep for an anchor. The Alkirk cycle miner is produced by Lawrence Machine and Manufacturing Co., Seattle, Wash.

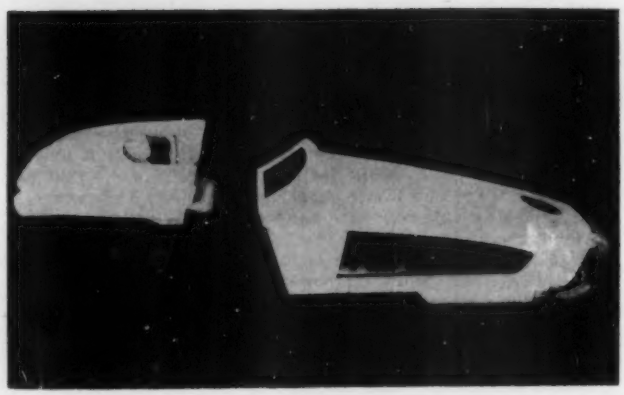
Turbine power for pushbutton tractor



Hydrostatic transmission coupled to gas turbine results in tractor that has no gear shifting, no throttle, no brake or clutch pedal. Despite the lack of controls, infinitely variable speed selection is achieved.

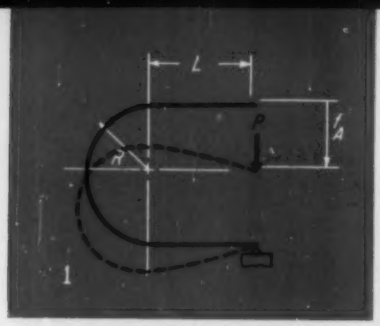


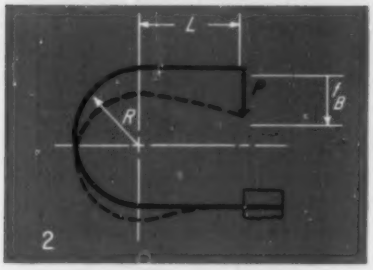
PUSHBUTTON to start the tractor triggers an automatic sequence to energize starter and ignition circuits in correct sequence. With a constant-speed power source the conventional throttle is eliminated. All movement is controlled by the transmission lever which regulates direction, forward or reverse, speed and stopping. Once the desired direction and speed have been selected the operator only has to steer the tractor. Response to the transmission control is immediate throughout its speed range, 11 mph top. IH personnel are, from left: John R. Cromack, test engineer; Carl H. Meile, chief engineer; and Ralph E. Wallace, research engineer.

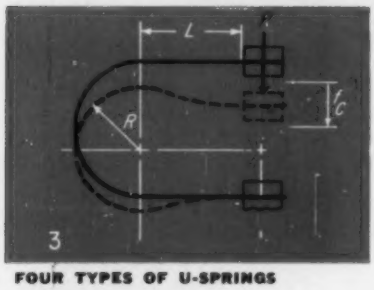


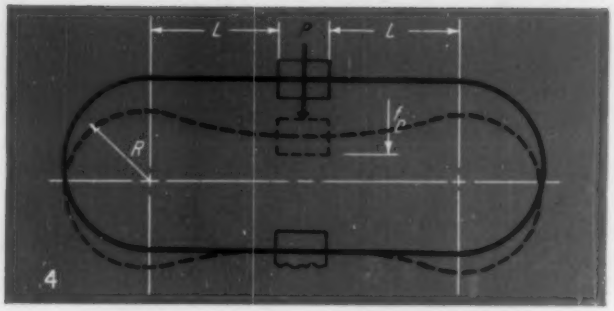
SMALL SIZE of turbine permits a low, forward-sloping hood line that provides excellent visibility for the operator. This configuration would prove impractical with the conventional water-cooled piston engine. The turbine engine needs little servicing and so the hood can completely enclose it—this contrasts with the traditional open sides of farm tractors. Skin is molded fiberglass with aluminum nose section. One piece rear end includes the fenders. Slots in rear fenders give operator a full view of hitch.

PS . . . The gas turbine used is an 80-hp, single-shaft unit 21 in. long, 13 in. dia weighing 90 lbs with reduction gears. Gearing reduces the turbine speed to 2000 rpm to turn a variable-displacement pump. Farm tractor is powered by a Titan T62T gas turbine produced by Solar Aircraft Co. Tractor is produced by International Harvester Co, Chicago, Ill.









FOUR TYPES OF U-SPRINGS
1—Simple-simple, type A
2—Cantilever-simple, type B
3—Cantilever-cantilever, type C
4—Double cantilever-cantilever, type D

NEW EQUATIONS for U-SPRINGS

They bring together key design parameters and offer, with the aid of a chart, quick determination of spring dimensions.

JOSEPH E FLECKENSTEIN,
Staff mechanical engineer
Johnson Service Company, Milwaukee, Wisc

■ U-springs offer linear force-deflection characteristics that make them especially useful in instruments and precision measuring devices. In addition, they are easily mounted, and can be manufactured from strip metal with relatively simple machinery.

The new equations and chart presented here offer a quick and direct method for determining the spring dimensions when given a set of values for maximum stress, deflection and load at deflection—the parameters usually known to the designer. The data apply to U-springs of rectangular or circular cross-section (by far the most common sections employed) and are based on a series of general equations presented at the 1960 ASME Annual Meeting (paper 60-WA-172).

End conditions of U-springs may be of simple-beam type, cantilever-beam type, or combinations thereof. This leads to four basic types of springs, illustrated above. Their deflections, *f*, can be determined by one of the following equations, which are applicable to any type of cross-section:

Simple-simple type (Type A)

$$f_A = \frac{PR^3 C_1}{EI}$$

Cantilever-simple type (Type B)

$$f_B = \frac{PR^3 C_1}{EI}$$

Cantilever-cantilever type (Type C)

$$f_C = \frac{PR^3 C_2}{EI}$$

Double cantilever-cantilever type (Type D)

$$f_D = \frac{PR^3 C_2}{2EI}$$

Symbol list is on page 81. Factors C_1 and C_2 are dimensionless deflection constants equal to

$$C_1 = \frac{2}{3}K^3 + \pi K^2 + 4K + 1.5708$$

$$C_2 = \frac{2}{3}K^3 + K^2 - 0.4292 + [2-K^2]\left[\frac{K^2+2K+1.1416}{\pi+2K}\right]$$

Type-D spring produces no twisting along the axis of displacement and no moment perpendicular to the axis of displacement, unlike most helical springs which produce torques in both planes. This feature avoids frictional forces at guides and pivots when employed in instrumentation.

Maximum moments for the four spring types are:

Types A and B

$$M_A = M_B = PRU_1$$

Type C

$$M_C = PRU_2$$

Type D

$$M_D = \tfrac{1}{2}PRU_2$$

where U_1 and U_2 are dimensionless moment constants equal to

$$U_1 = 1 + K$$

$$U_2 = \frac{2 + \pi K + K^2}{\pi + 2K}$$

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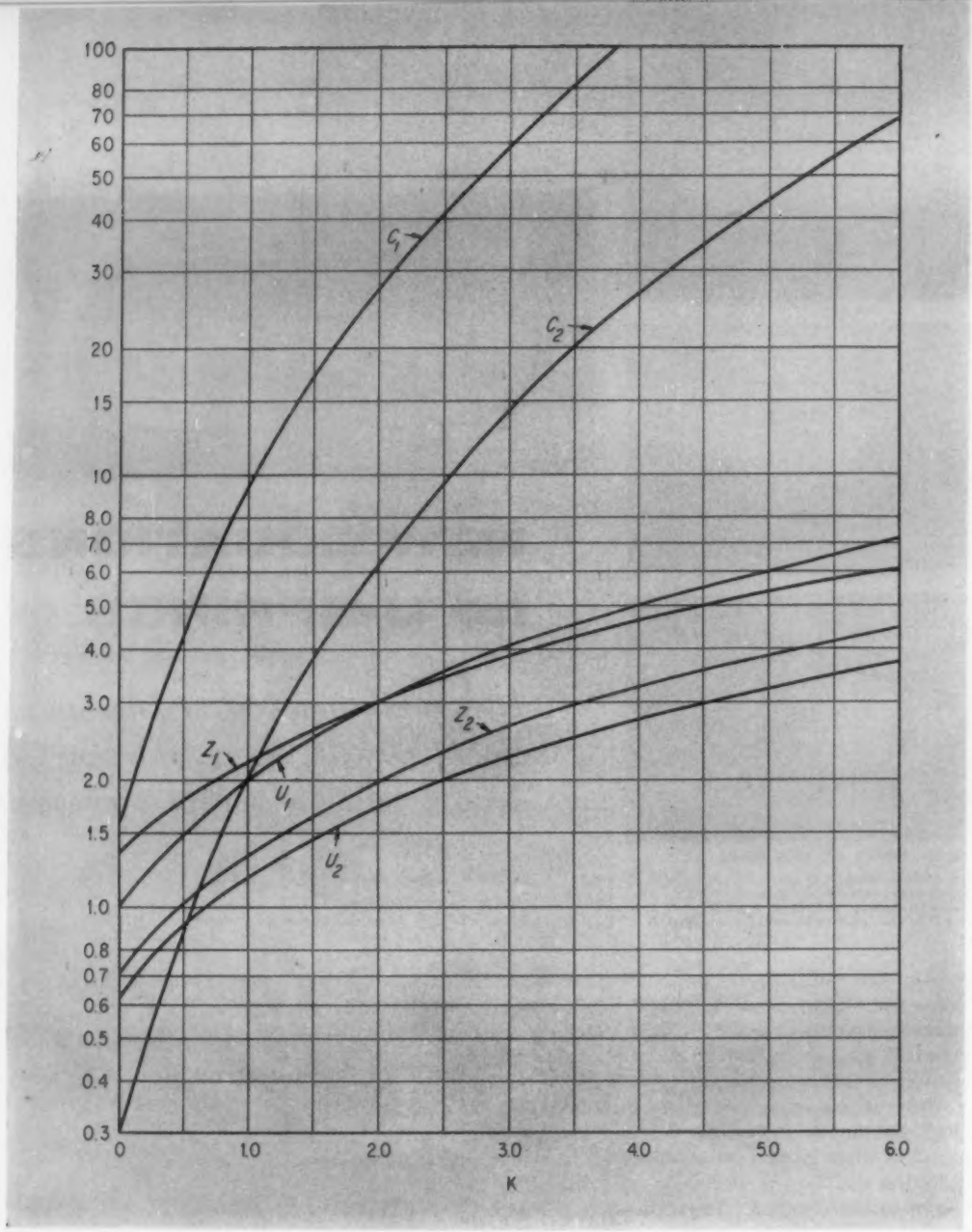


The resulting stress can be then calculated from:

$$s = \frac{Mc}{I}$$

Although the above deflection and moment equations can be applied directly to a U-spring of any given dimension to compute s or f, the reverse calculation—when a combination of R, L and I must be determined for a desired set of values of P, f and s—is much more cumbersome. A simplification is possible, however, if a particular shape of cross-section is considered.

For circular cross-sections

For a U-spring of a circular cross-section, $I = 0.049d^4$, where d = outside diameter of cross-section. Consequently,

Type A and B springs

$$\frac{RC_1^{3/5}}{U_1^{4/5}} = \left[\frac{P\,(0.049Ef)^3}{(0.098s)^4}\right]^{1/5}$$

Type C spring

$$\frac{RC_2^{3/5}}{U_2^{4/5}} = \left[\frac{P\,(0.049Ef)^3}{(0.098\,s)^4}\right]^{1/5}$$

Type D spring

$$\frac{RC_2^{3/5}}{U_2^{4/5}} = \left[\frac{P\,(0.098Ef)^3}{(0.196\,s)^4}\right]^{1/5}$$

For rectangular cross-sections

For a U-spring of a rectangular cross-section, $I = \frac{1}{12}\,bh^3$, where b = section width, h = section height. Hence,

Types A and B

$$\frac{Rb^{1/3}\,C_1^{2/3}}{U_1} = \frac{6\,[P\,(Ef)^2]^{1/3}}{12^{2/3}\,s}$$

Type C

$$\frac{Rb^{1/3}\,C_2^{2/3}}{U_2} = \frac{6\,[P\,(Ef)^2]^{1/3}}{12^{2/3}\,s}$$

SYMBOLS

b = width of rectangular cross-section, in.
c = distance from neutral axis to extreme fiber
C_1, C_2 = dimensionless deflection constants
d = outside diameter of circular cross-section, in.
E = Modulus of elasticity, psi
f = deflection of spring, in.
h = height of rectangular cross-section, in.
I = moment of beam cross-section about neutral axis, in.^{4}
$K = L/R$
L = length of straight portion of U-spring, in.
M = moment, in.-lb.
P = load, lb.
R = spring radius, in.
s = maximum fiber tensile stress, psi
U_1, U_2 = dimensionless moment constants

Type D

$$\frac{Rb^{1/3}\,C_2^{2/3}}{U_2} = \frac{3\,[P\,(Ef)^2]^{1/3}}{6^{2/3}\,s}$$

Design chart

To facilitate the plotting of key factors on a design chart, the following designations are made for U-springs of circular sections:

$$Z_{1c} = \frac{C_1^{3/5}}{U_1^{4/5}} \qquad Z_{2c} = \frac{C_2^{3/5}}{U_2^{4/5}}$$

For U-springs of rectangular sections:

$$Z_{1r} = \frac{C_1^{2/3}}{U_1} \qquad Z_{2r} = \frac{C_2}{U_2}$$

Note that $Z_{1c} \approx Z_{1r}$, and $Z_{2c} \approx Z_{2r}$. Therefore, new symbols can be introduced

$$Z_1 = Z_{1c} \approx Z_{1r} \qquad Z_2 = Z_{2c} \approx Z_{2r}$$

The values of Z_1 and Z_2 are plotted, along with values of C_1, C_2, U_1 and U_2, in the design chart on the preceding page to aid in performing rapid computations. The previous equations now become:

Types A and B, circular cross-section

$$Z_1 R = 1.049\left[\frac{P\,(Ef)^2}{s^4}\right]^{0.2}$$

Type C, circular cross-section

$$Z_2 R = 1.049\left[\frac{P\,(Ef)^2}{s^4}\right]^{0.2}$$

Type D, circular cross-section

$$Z_2 R = 0.9138\left[\frac{P\,(Ef)^2}{s^4}\right]^{0.2}$$

Types A and B, rectangular cross-section

$$Z_1 Rb^{1/3} = \frac{1.144}{s}\,[P\,(Ef)^2]^{1/3}$$

Type C, rectangular cross-section

$$Z_2 Rb^{1/3} = \frac{1.144}{s}\,[P\,(Ef)^2]^{1/3}$$

Type D, rectangular cross-section

$$Z_2 Rb^{1/3} = \frac{0.9085}{s}\,[P\,(Ef)^2]^{1/3}$$

With the above relationships it is possible to determine the necessary values of R and L, and, from the deflection equation or moment equation, the corresponding values of d, for circular sections, or h and b, for rectangular sections.

SAMPLE PROBLEM

A spring of Type A is to be designed such that

P = 30 lb
f = 0.35 in.
s = 80,000 psi
E = 30.0 × 10^6 psi
R = 1 in.
L to be under 3 in.
b to be near 0.50 in.

Thus

$$Z_1 Rb^{1/3} = \frac{1.144}{s}\,[P\,(Ef)^2]^{1/3}$$

$$Z_1 b^{1/3} = 2.131$$

If $b = 0.50$ in., then $Z_1 = 2.69$, and from chart:

$$K = 1.57 \qquad C_1 = 18.17$$

Therefore

$$I = \frac{PR^3\,C_1}{Ef} = 5.19 \times 10^{-5}$$

Solving for h

$$I = \frac{bh^3}{12}$$

If b = 0.50 in.
h = 0.1076 in.

Generally, U-springs of rectangular cross-section are made from sheet or strip stock. Thus, it is necessary to choose the nearest standard thickness. In this case, the nearest is $h = 0.1019$ in. If h is fixed, then there is only one value of b which will satisfy all the imposed conditions, and it is best determined by a trial and error procedure.

Consider $b = 0.520$ in. This gives $Z_1 = 2.65$.

From the chart, $K = 1.56$ and $C_1 = 18.6$. Hence, $I = 4.49 \times 10^{-5}$.

However

$$f = \frac{PR^3\,C_1}{EI} = 0.414 \text{ in.} \quad \text{(too high)}$$

Try $b = 0.560$ in. This gives: $Z_1 = 2.58$, $K = 1.45$, $C_1 = 16.0$, $I = 4.86 \times 10^{-5}$.

Deflection is

$$f = 0.329 \text{ in.} \quad \text{(too low)}$$

Try $b = 0.543$ in. This gives $Z_1 = 2.611$, $K = 1.493$, $C_1 = 16.76$, $I = 4.78 \times 10^{-5}$.

This results in the desired value for deflection:

$$f = 0.350 \text{ in.}$$

Consequently, the dimension requirements become:

h = 0.1019 in. $\qquad R$ = 1.000 in.
b = 0.543 in. $\qquad L$ = 1.493 in.
K = 1.493

For REPRINT of above article, just check 621 on one of the Reader Service cards found in this issue.

EDITOR'S NOTE: For information on dimensions, materials and cost of springs made from strip metal see:

Functional Gaging for Flat Springs, Dec '57, p 76—Describes the inspection-gage method for dimensioning complex-shape flat springs.

One Spring Returns Hand Lever, Part I—Nov 21 '60, p 109, Part II—Dec 5 '60, p 89—Designs using only a single spring—flat, helical or torsion.

Flat Spring Material—Costs and Stress Factors, Oct 14 '57, p 125—Effect of thickness on cost for steel and nonferrous alloys; stress factors for various bend radii.

Formability of Flat Spring Material, Sep 16 '57, p 125—Compares various hardnesses of strip steel.

—Nicholas Chironis

what's coming in

CONDUCTORS to 1000 F

It's no problem today to find electrical conductors for the 500-F range, and good durable materials to insulate them. But when the temperature rises to 600 F and above, the going is likely to be rough. Here's the latest on materials available and problems in selection and use.

ANNESTA R GARDNER
Associate editor

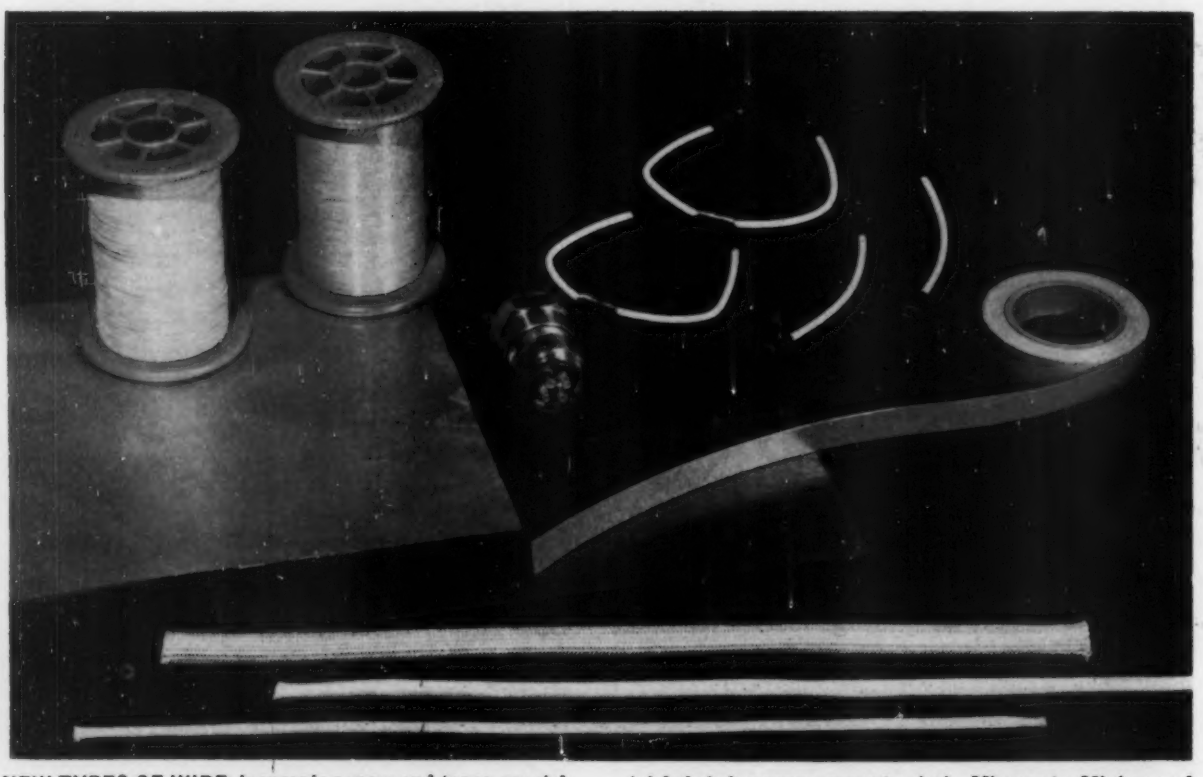
■ If 500 F is the specification, you'll have few problems today in filling the bill with efficient conductors that will provide long-term service. Flexible insulating materials, using fluorocarbon plastics, silicones, glass, mica, and asbestos, are giving excellent performance at that level. Some will even stand higher temperatures for short periods.

But if the specification calls for long-term service at 500 C (930 F) or even 600 F, watch out. There are inert materials—ceramics and refractories (including porcelains and cold-molded compositions) that can stand the heat. But these are, in general, rigid.

Flexible insulating materials, even for short-term service at 600 to 700 F, are few and far between, and the selection is small indeed for 800 F and above. Those that do exist pose plenty of problems.

Almost all flexible insulating systems for high temperature involve an inert material (glass, mica, asbestos) with a flexible binder—and the binders almost all evaporate or degrade after even a few hours at the upper end of the range (800 to 1000 F). They may still supply sufficient insulation if there is no flexing and no thermal cycling. But, if they are flexed, they may crumble; and if they are brought back to room temperature, they may stiffen, crack, and deteriorate electrically to the point where they become useless. Furthermore, organic binders may carbonize so tracking becomes a serious problem.

Even all-inert braided sleeving may cause trouble. If



NEW TYPES OF WIRE, inorganic papers and tapes, special glass and ceramic fiber sleeving, and new-type connectors are all under development to meet high-temperature needs. The materials shown here are from Sprague Electric (nickel-clad copper magnet wire), Minnesota Mining and Raybestos (mica, asbestos, and ceramic papers), Bentley-Harris (glass fiber sleeving), Bendix-Scintilla and AMP (connectors and terminals).

the braid angle is less than 50 deg, the sleeving may tighten and buckle, breaking the wires inside.

The conductor, too, must be specially chosen—and protected—for high-temperature applications. Generally, that means starting with special wire, coated to prevent oxidation. Here, though, a good deal of progress is being made.

Good magnet wire is available

For magnet wire, there are new fluorocarbon enamels that stand extended exposure in the 500- to 600-F range and temperatures to 700 F for short periods.

Anodized aluminum is giving good service at 930 F. However, the oxide coating is relatively fragile so that anodized wire does require protection.

Ceramic-coated nickel-clad copper seems able to stand 1000 F or more but it does have lower electrical conductivity than a standard copper conductor of the same size. (Nickel-plated and silver-plated copper have excellent conductivity ratings but most conductors of this type are limited to temperatures below 800 F, even when protected by a ceramic coating.)

New coating systems under investigation—electrophoretic silica, extruded boron nitride, and the like—look promising but they are far from commercial application (see below).

For miniature lead wire, many new combinations are in development and under test. Fluorocarbon-enameled, glass-and-mica-wrapped, nickel-clad copper looks good for temperatures at least to 800 F. Fiber-cored, ceramic-coated wire may stand even higher temperatures for longer times.

To provide aircraft transformer coils, that will serve in the 930-F range, new encapsulation and impregnation techniques are being developed, with some new systems involving combinations of the two. Westinghouse, for instance, is testing a system in which coils are first wound, then encapsulated in a porous ceramic, and then vacuum-impregnated with molten glass.

WHY IT'S A PROBLEM

As the temperature heads upward from 500 F:

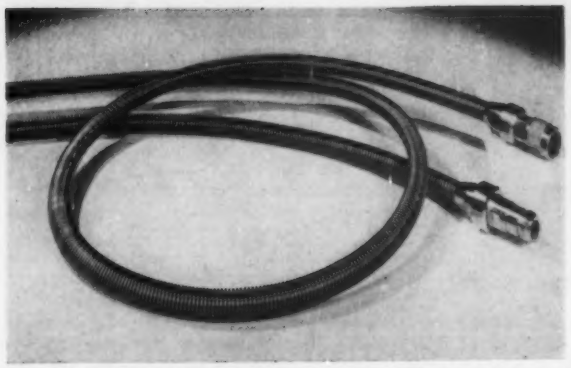
- **Nonconductors become conductors.**
- **Binders evaporate, leaving stiff, fragile shells that provide little protection or insulation, or carbonize and promote "tracking."**
- **Coatings migrate into wires, reducing conductivity.**

The problem is further complicated by the fact that some of the materials that are best at elevated temperatures do not do well at room temperature—they pick up moisture or lose flexibility.

What's being done?

- **Methods are being found to compensate for some of the most serious shortcomings of present-day materials.**
- **New materials are being developed—for conductors as well as insulation.**
- **New design approaches—including sealed systems—are being tried.**

On these pages, progress and problems are outlined to help you find the best solution for your products.



FOR 1000-F SYSTEMS sealed cable like this Amphenol unit must frequently be used. It's made in standard lengths, is supplied fully sealed, complete with its own connectors.

Connectors stand very high temperatures

Development of connectors and terminals is keeping pace with high-temperature wire.

At least three companies—AMP, Amphenol-Borg, and Bendix-Scintilla—supply connectors in the 1000-F range (see photograph) and Bendix has a ceramic series for 1250 F. Even higher-temperature units have been made and tested—to 1750 F—but they are not in production.

Spearheading a major effort to develop other high-temperature electrical equipment is North American Aviation. It is primary contractor for the Air Force HOTELEC (High Temperature Electrical Equipment Development Program) and working with it are such companies as GE, Westinghouse, Lewis Engineering, Burndy, and Autolite.

Under this program, a number of components are being developed for ues in 400-cycle systems at 600 F and above. Prototype wiring at 600 F is already under test, as are 850-F terminals.

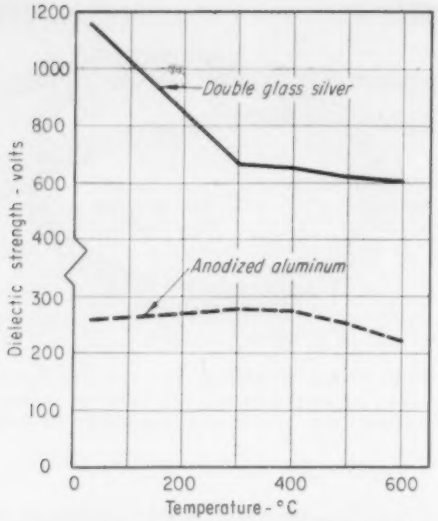
Navy has a major electrical materials-testing program under way at Brooklyn Navy Yard that has already uncovered much useful information on magnet wire and lead wires. Other independent programs are underway, too.

But there are problems

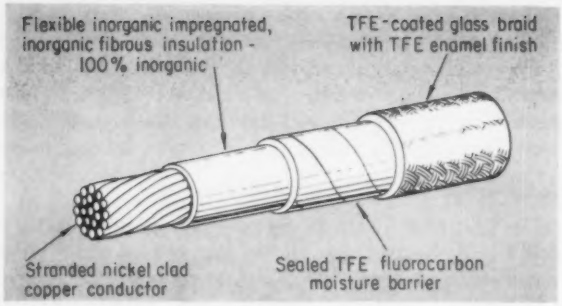
Each of the wire and coating systems has its limitations. Most of the glass wraps are relatively bulky and have little resistance to thermal cycling. Furthermore, at high temperatures glass becomes electrically conductive, and also reacts with silver wire, causing embrittlement. Bonding agents evaporate, leaving a fragile shell. Here, new bonding compositions—phosphate systems and perhaps colloidal alumina—may help a good deal. Such materials may also help in development of new high-temperature "enamels" for magnet wire. But a good many of these inorganic binders have a tendency to pick up moisture which must be carefully watched.

The anodized aluminum coatings have fair flexibility and heat resistance, but the coating is thin so voltages are limited; abrasion resistance is low, and moisture resistance leaves something to be desired.

Silver wire has good conductivity and offers the advan-



GLASS-SERVED SILVER WIRE IS COMPARED WITH ANODIZED ALUMINUM in this test plotting by General Electric (Ft. Wayne). Though anodized aluminum displayed outstanding electrical properties and thermal stability, and took up no extra space, GE gives top rating to the glass-served silver. Processing and application still pose problems with aluminum. Big drop in dielectric strength of the glass-served wire above 600 F is attributed to vaporization of the silicone varnish used to bond it.


Flexible inorganic impregnated, inorganic fibrous insulation - 100% inorganic
TFE-coated glass braid with TFE enamel finish
Stranded nickel clad copper conductor
Sealed TFE fluorocarbon moisture barrier

800-F LEAD WIRE combines metals, plastics, and inorganics in the four-part Lewis Engineering system illustrated here. For still higher temperatures, Lewis uses all-inorganic multilayered systems.

tage that its oxide reduces back to the pure metal at high temperatures. But cost is a problem, and so is silver migration.

Long-term exposure of nickel-clad copper wire may result in diffusion of nickel into the copper, with resulting loss of conductivity. For this reason, such combinations as high-purity chrome plate, and anodized tantalum and columbium on copper and silver are under test. New ceramic coatings will be needed, though, to provide protection for such systems.

For lead wire, fibrous felts and cloth offer fair-to-good flexibility and heat resistance, but the bonding agents used to strengthen may also tend to stiffen them, increase moisture pickup, or add other undesirable properties.

Even when it is possible to take advantage of the rigid, inert materials, it's not all smooth sailing. Ceramic-bonded mica may, for instance, swell under heat to a point where insulated cables require 30 or 40% more space after high-temperature exposure than they do initially. As a matter of fact, even where materials don't swell, satisfactory high-temperature performance almost always involves thicker insulation and greater spacing between conductors than are necessary in the under-500-F range. The over-all increase in the size of an insulated assembly for this reason may be as much as 50%.

What's ahead?

Most experts agree that the best hope lies in development of improved wire and better ceramic coating—extensions of the progress outlined here.

For instance, it may be possible to develop combination coatings that will do the job. Westinghouse is working on pigmented polyester resins (metal-modified compositions, heavily loaded lead borate glass frit and a silica refractory) which look very good for 600 F and may go to 930 F. The polyester, of course, burns out. But the remaining inorganic enamel seems to offer good protection.

Armour Research Foundation is testing electrophoretically deposited alumina and silica coatings and an extruded boron nitride coating bonded with phosphates and fluororganics.

Raytheon is working on the anodized tantalum and columbium coatings and the chrome-plated silver and copper mentioned above.

Choosing the system

Finding a satisfactory insulating system for the 1000-F range is not going to be easy. As Robert W. Anderson and Allen Hubbard III of Lewis Engineering point out in an excellent review of the subject: Conductors for the 600- to 1000-F range must not only be heat resistant but also must meet specifications on conductivity, temperature coefficient of resistance, magnetic permeability, thermal stability, tensile strength, elongation, flexibility, specific heat, density processability, and availability.

The insulation must also be thermally stable, strong, flexible, available, and easy to fabricate. In addition, it needs a specific dielectric strength, dielectric constant and dissipation factor, heat transfer characteristics, flammability abrasion, moisture, and solvent resistance.

Price is a problem

To all of these, should be added the factor of cost. And that may be a big factor indeed. The least expensive of the high-temperature lead wires usually costs 2 to 3 times as much as those designed for the conventional range. Some of the newer materials—insulating tapes, for instance—carry a developmental price of $5 to $10 a foot; and specialty wire, even when not incorporating precious metals, is generally far from cheap.

What's the answer?

After an extensive survey of 600-to-1000-F insulating systems, Anderson and Hubbard concluded that, for 600 to 850 F, a silicone-impregnated asbestos wrapping, covered by Teflon tape and overbraided with Teflon-coated

and impregnated glass—by no means a simple assembly—is probably the best current solution.

For 850 to 1000 F, they recommend a composite insulation consisting of glass-backed mica tape applied helically about the conductor with an over-binder of inorganic fibrous insulation such as asbestos and a flexible metal sheath over-all.

Rockbestos, too, uses Teflon and Teflon-coated glass braid in its 600-to-800-F insulating system, along with inorganic fibrous insulation; and, for the 1000- to 2000-F range, it has a nickel-clad copper conductor, sheathed in flexible inorganic fibrous insulation and covered by a special ceramic fiber braid.

Boston Insulated Wire & Cable Company's 1000-F "Superjet" wires also use nickel-clad copper and inorganic fibrous insulation in a double-layered combination.

The fact that so much work is underway in so many places means that 1000 F itself may be only a temporary barrier and that conductors for even higher ranges may soon be available. That's important not only for those designing high-temperature equipment, but also for those who need durable components for long-term service in the moderate temperature range.

EDITOR'S NOTE: For information on standard electrical insulating materials, to and perhaps slightly above 500 F, see:

How to choose the right electrical insulation, Apr 10 '61, p 41; a comprehensive report on plastics, ceramics and dielectric fluids.

For more on high-temperature electrical components, see:

High-temperature electrical equipment, Sep 26 '60, p 56, which discusses motors, solenoids, and transformers, and charts performance of magnetic and electrical materials.

Hot solenoid, Jan 6 '58, p 61, a discussion of a long-life unit for the 500 F range.

WHERE TO GET INFORMATION ON THE HIGH-TEMP WIRE

Materials suppliers, government agencies, research foundations, and a number of companies conducting their own and government research programs are among the sources of information on high-temp wiring and insulation. The list below is not complete, but it will serve as a starter.

Magnet wire

Among the companies now supplying, or preparing to supply, magnet wire for 500 F and above are American Super-Temperature Wires, Anadite, Anodyne, Electric Autolite, Handy & Harmon, Hi-Temp Wires, International Wire, National Standard, Permaluster, Phelps Dodge Copper Co, Rea Magnet Wire Co, Secon Metals, Simplex Wire & Cable, Sprague Electric, Sylvania, Warren Wire, and Westinghouse.

Lead Wire

High-temperature lead wire is being developed by Acro Research, American Super-Temperature Wires, Amphenol, Anaconda, Boston Insulated Wire, Electric Autolite, General Electric, Lewis Engineering, and Rockbestos.

Insulation

Suppliers of special fibrous insulating materials (other than plain glass and asbestos fibers) used or under test for such wire include Amersil, AMP, Bentley-Harris Mfg. Co, Carborundum, Emerson & Cuming, General Electric, Haveg Industries, HI Thompson, Johns-Manville, Knowlton Bros, Libbey-Owens-Ford, Raybestos-Manhattan, and Varflex.

Research and publications

Companies actively researching the field to develop improved wire for their own and government use include General Electric, Lewis Engineering, McGraw-Edison, North American Aviation, Raytheon, Thompson Ramo Wooldridge, and Westinghouse.

Much work is also under way at Armour Research Foundation, Battelle Memorial Institute, Georgia Institute of Technology, U of Florida, U of Illinois, and several other research labs.

A number of reports on government-sponsored research on high-temperature wire are also available from OTS, Department of Commerce, Washington 25, D. C. Among them, Georgia Tech reports PB151944 ($1.25) and PB161788 ($1.00), both published last year, and University of Illinois reports PB131811 ($2.00) and PB151943 ($1.50), published in 1958 and 1959.

HERE ARE THEIR ADDRESSES

Aero Research Instrument Co, Inc, 315 North Aberdeen St, Chicago 7, Illinois
American Super-Temp Wires, Winooski, Vermont
Amersil, Englehardt Industries, Hillside 5, N.J.
AMP, Inc, Harrisburg, Pennsylvania
Amphenol-Borg Electronics Corp, Broadiew, Illinois
Anaconda Wire & Cable Co, 25 Broadway, New York 4, N.Y.
Anadite Inc, 10647 Garfield Ave, South Gate, Calif
Anodyne Inc, North Miami Beach 69, Fla
Armour Research Foundation, Chicago 16, Illinois
Battelle Memorial Institute, 505 Kind Avenue, Columbus, Ohio
Bentley, Harris Mfg Co, Conshohocken, Penna
Boston Insulated Wirs & Cable Co, Bay Street, Boston 25, Mass
Carborundum Co, The, Latrobe, Penna
Electric Autolite Co, The, Toledo 1, Ohio
Emerson & Cuming Inc, Canton, Mass
General Electric, Bridgeport 2, Conn
Georgia Institute of Technology, Atlanta, Ga
Handy & Harmon, 82 Fulton St, New York, N.Y.
Haveg Industries, Wilmington, Delaware
Hi-Temp Wires, Westbury, Long Island
HI Thompson Fiber Glass Co, 1733 Cordova St, Los Angeles 7, Calif
International Wire Products Corp, Greenwood Ave, Midland Park, N.J.
Johns-Manville, 22 East 40 St, New York 16, N.Y.
Knowlton Bros, 213 Factory St, Watertown, N.Y.
Lewis Engineering Co, The, Naugatuck, Conn
Libbey-Owens-Ford, Toledo, Ohio
McGraw-Edison, 800 Kind Avenue, Columbus 16, Ohio
National Standard, Niles, Michigan
North American Aviation, Inc, International Airport, Los Angeles 45, Calif
Permaluster, 2012 W. Burbank Blvd., Burbank, Calif.
Phelps Dodge Copper Co, 4400 New Haven Ave, Ft Wayne, Ind
Raybestos-Manhattan Inc, Manheim, Penna
Raytheon Co, Lexington 73, Mass
Rea Magnet Wire Co, Ft Wayne, Ind
Rockbestos Wire & Cable Co, New Haven 4, Conn
Secon Metals Corp, 7 Intervale St, White Plains, N.Y.
Simplex Wire & Calbe Co, 1200 Shames Dr, Westbury, N.Y.
Sprague Electric Co, Bennington, Vt.
Sylvania Electric Products Inc, 12 Second Ave, Warren, Penna
Thompson Ramo Wooldridge Inc, 1845 E 30 St, Cleveland 14, Ohio
University of Illinois, Urbana, Illinois
Varflex Corp, Rome, N.Y.
Warren Wire Co, Pownal, Vermont
Westinghouse-Electric Corp, 3 Gateway Center, Box 2278, Pittsburgh 30, Penna

WHY AND HOW TO COMPUTE VE SAVINGS

Proof of value-engineering savings is more difficult than proof of value-analysis savings. Here the major source of the difficulty is identified and approaches suggested for documentation

DR C C VAN VECHTEN
Engineering Dept, TAPCO
Div of Thompson Ramo Wooldridge Inc., Cleveland 17

■ Computing saving for value engineering programs presents much greater difficulties than for value analysis ones. "Value engineering" is used here to mean functionally oriented efforts to remove production cost *before* release of designs to production; the term "value analysis" is reserved for comparable efforts made *after* design release, usually after there has been some production.

Although there are many minor variations, the basic formula for determining savings assignable to value analysis programs is quite simple and straightforward: *Multiply the known existing cost of the item by the number of parts remaining to be made* (in a purchase order or in a year) *and from this subtract the sum of the new cost to make the same items plus all the costs* (documentation, tooling, additional testing, VA effort, etc) *of making the change.* The difference is the saving attributable to VA. It is customary to divide the net saving by direct cost of the VA effort to get a performance ratio.

ABOUT THE AUTHOR

Dr Courtlandt C Van Vechten was assistant director (top civilian) of the Quality Control Division, BuOrd (now the Bureau of Naval Weapons) from 1946 until 1958. For three years prior to that he served as a Lt-Cdr in the Navy and as first director (acting) of its Quality Control Division. He earned his BA in 1929 and his MA in 1930 at University of Michigan, and his doctorate from the University of Chicago in 1935 while serving as a statistician for the State of Illinois. From 1936 to 1940, Dr VanVechten taught statistics at Wayne State University in Detroit. One of the early members of the American Society for Quality Control, he has been active in that organization for about 15 years. He is a psychologist, an accomplished mathematician and statistician, with a long-time interest in value engineering. He joined TAPCO in 1958, assigned to its Value Engineering program.

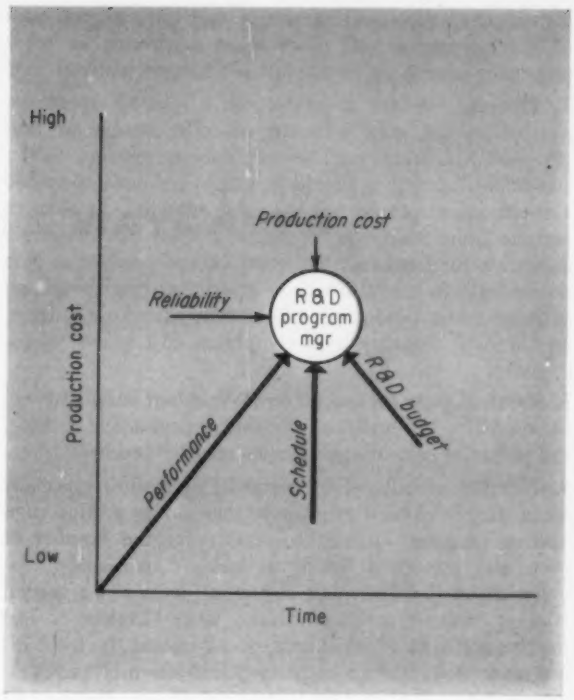
Given sufficient foresight, any cost improvement possible under a VA program could have been made under a VE one. It is equally clear that improvements made in the preproduction-release period save much more than the same improvement made after tooling has been bought, final drawings prepared, factory routings and cost standards established, etc. And, within the prerelease stages, the earlier the improvement is made the more profitable it is. What may not be so clear is that **it is both more difficult and more expensive to document the savings of a VE program than of a VA one.** Yet, no program can expect to receive strong and continuing management support without substantial documentation of its contribution to corporate objectives. And the documentation must be accomplished at a very modest cost.

The Armed Services and their vendors are rapidly coming to the realization that **a substantial and increasing preponderance of military funding is going into items produced in jobshop quantities,** as distinct from the mass production which characterized military procurement as recently as Korea. They are further realizing that **a consequence of the jobshop quantities is the fact that most of the profit from value improvement is lost if the improvement is not made before design release.** Many potential improvements must be made then or not at all, because the costs of making changes are frequently too great to be carried by the small volume of production.

For example, we studied a series of proposed changes on a rather complicated Army device and found that **the costs of changing drawings varied from 42% to 72% of the total cost of the proposed changes.** Where extreme documentation is required, it may be uneconomical even to eliminate a nonfunctional characteristic.

R & D can't minimize production cost

It is easy to say that good design work includes consideration of making the product at minimum cost. Most



FIVE VECTOR PRESSURES affect efforts of the R & D program manager. They tend to push costs up and lengthen time.

engineering supervisors accept this and are quick to defend their subordinates' work in this area. Analysis of the vector sum of the pressures on a typical Defense Industry R & D project manager, as those pressures affect production cost, will show why **such groups cannot be expected to optimize production cost** (see sketch). That they do not is amply demonstrated by the savings realized on items where production volume has permitted VA programs. This point is worth further consideration.

In a typical military R & D program, the greatest single pressure operating on the program manager is the need to meet performance requirements. These usually imply significant advances in the state of the art. As a vector force, this pressure operates to increase the cost and time to do the job. Second in magnitude is, typically, pressure to meet schedules. Frequently holding schedule means trying to buy time, a most expensive commodity.

Next in importance, as seen by the R & D project manager, is likely to be his budget. The days when cost-plus-fixed-fees research programs could be allowed to run on without much concern over cost overruns are long gone. This pressure operates to force attempts to minimize engineering costs and to stay on schedule; both are adverse to the things one would like to do to minimize production cost. Fourth is likely to be the pressure for reliability. High reliability typically implies simplicity and with that usually goes reduced production cost. On the other hand, efforts to maximize reliability can also lead to higher-priced materials and greater precision, with its attendant costs, and reliability can be a serious pressure on schedules. In sum, reliability is no better than neutral in its net effect on production cost.

In the face of the rapid pace of technology and the development of specialty vendors, even what effort is put on reducing production cost may be largely misapplied by designers who simply cannot keep up with all the details of production technology. Finally, there is the fact that the R & D program manager is frequently severely limited in his freedom of action by resident technical representatives of his customer; men with authority to add cost and time to the program but without responsibility for either cost or schedule.

Increasingly, the conclusion is being reached that a separate value engineering group operating at all stages *prior* to design release is a must if the released design is going to be competitive. But here no simple or readily available before-and-after cost comparisons are possible. For one thing, the interaction between the R & D design and the value engineering personnel that is essential for effective VE performance precludes any sharp, clear-cut assignment of responsibility for improvement between the two. Secondly, it may be most difficult to assign dollar values to such items as conservation of scarce materials, weight savings and reduction of procurement and manufacturing lead time even when these are recognized as valuable contributions. Finally, it is hard or impossible to justify the cost of developing detailed cost figures for production of discarded designs. Yet the need remains for value engineering to develop yardsticks to justify its existence.

The value of value

It is clear that no single yardstick of the value of a value engineering program is going to be readily available. A number will be suggested; they should be used with judgment depending on the individual situation. Above all, we must avoid the very poor value involved in too-expensive, complicated, and rigid programs. It is equally important not to defeat the effectiveness of the VE organization by claiming credit for so much that the R & D people develop hostilities and resistances. There is no more intellectually honest group in our society than design engineers, and it seems a safe rule to say that "**Value engineering should never claim credit for more of a contribution than the development-program manager is willing to concede.**" The relatively few instances where this rule may work unfairly seem to me far less important than the many where it will combine essential justice with effective cooperation.

1. Material—Where a less-expensive but equally effective material is substituted directly, straight cost comparisons can usually be obtained without undue effort. In most

instances, also, production people will have a good idea of any changes in cost of identical machining or other processing operations as a result of changed material.

2. **Processes**–Where a process, as a plating operation, can be omitted, good estimates of dollar savings are usually readily obtainable. They need not be accurate to the last decimal, but they should be obtained from responsible cost-estimation people, not the value analysts. As changes become more and more complex, it may be excessively expensive to detail out the costs of the processing it is decided not to use (although it is assumed that the design as approved for production will be fully costed out). Here, an "eyeball" estimate by a competent cost analyst seems in order.

3. **Standard parts for special ones**–Standard parts cost will be available. If really comparable experience is lacking, the potential cost of special ones may be "eyeballed."

4. **Number of parts**–For complex assemblies, especially when they have been extensively changed by a value engineering program, a straight counting of the number of parts may provide a significant measure of savings. An organization that has made numerous devices of a general type–eg, missile auxiliary power units–develops a feel for the unit cost of additional, or subtracted, parts. This feel may well take in inspection and assembly costs as well as parts procurement. And, of course, there is an almost automatic reliability bonus as the number of parts is reduced.

5. **Weight**–For many categories of product, weight is an excellent index of cost. In aircraft, and even more importantly in missiles, it may be desirable early in the design stage to establish a dollar value for a weight vs cost tradeoff. Thus, weight saved by a VE program may have a directly assignable value independent of its effect on production cost. Conversely, of course, a proposal to save cost may be downgraded or eliminated if it adversely affects weight.

6. **Documentation cost**–Any simplification of drawings saves money. Particularly, under some of the current military programs involving microfilming and modification of all drawings up through top assembly whenever any detail is changed; documentation can become a major factor in program cost. Savings in this area may be well worth noting.

7. **Tooling**–Where simplification permits less-expensive tooling or machines or high production rates, these factors can be reasonably estimated by a good production man.

8. **Reliability**–The simplification that characterizes a VE job contributes, almost always, to reliability. This may be an intangible plus, but in an increasing number of contracts where reliability requirements are spelled out, the program manager may see a tangible value in VE's contribution to meeting, or demonstrating, reliability requirements.

9. **Maintainability**–The Military is acutely aware of the cost of maintaining its equipment. Two dollars a year maintenance cost per dollar of purchase price has been a widely circulated figure applied to electronic equipment. On numerous advanced-weapons systems, availability has been so impaired by maintenance problems that the whole system has been questioned. Presumably, then, there is a substantial value to the customer in maintenance savings for every dollar taken out of production cost. A difficulty in this area is the fact that, as yet, procedures for effectively weighing maintainability at the time contracts are let are, for the most part, rudimentary in the extreme.

10. **Procurement and manufacturing lead time** – Time schedules for delivery of plans or prototypes are one of the more common and serious roadblocks to effecting changes based on value engineering inputs. The common argument is: "Yes, it would save money, but it's too late to change now–we just must meet schedules. Besides, holding up schedules would increase the over-all cost of the job far more than this change would save." This argument may be valid or it may be simply the defensive reaction of a man who feels already overloaded with work. It needs critical examination. Design changes do take time, but a switch to readily available materials or parts can often cut procurement lead time by far more than the time cost of making the design change. Similarly, a VE contribution to ease manufacture can often permit shortening of the production cycle by more than the time cost of making the change. Experienced project managers come to recognize and evaluate the apparently inescapable cost of time in their programs–this is why delays so uniformly translate into cost overruns. VE can properly be credited with this constant cost for any time periods by which it permits shortening the project time.

Certainly, not all of these are applicable on any one VE program. But, by selection from them, plus, perhaps, additions, I believe that figures can be developed which will stand up to critical examination at least to the extent that reasonable people will agree that there is no more evidence of overestimation than of underestimation. And, those figures can be obtained without undue cost or conflict. They do provide a basis for the sort of reporting that, I believe, is essential to effective continued management support.

Basic rules

Whatever the details used to develop the report to management, try to observe these rules:

1. Determine figures objectively where possible.
2. When estimates are used, show the basis for estimating and identify the estimator.
3. Don't make value engineering the measure of its own success.
4. Obtain and note the agreement of the engineering project leader with the claims for the value engineering contribution.
5. Make the report short, simple, easy to read, graphic.
6. Examples and illustrations have their place.
7. Be generous with credit to individuals outside the VE group who have assisted the VE effort. Name them.

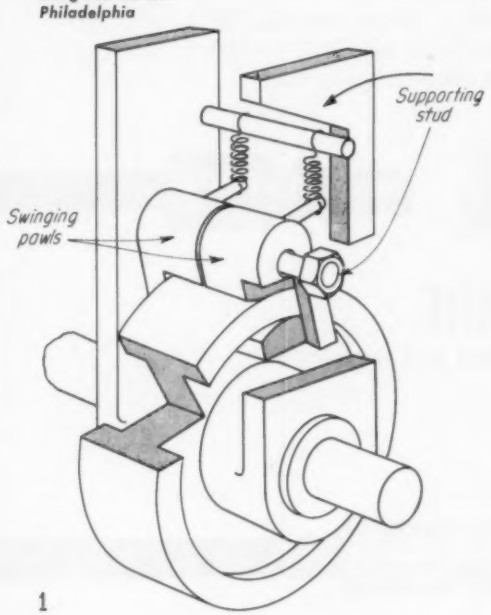
EDITOR'S NOTE: For a basic discussion of VE, VA and their relationship to design, to reliability and other functions, see:

Value, the Emerging Emphasis in Design, May 15 '61, p 79—Based on interviews with 80 men, this special report relates design engineering to the various service and checking functions. Available also as a 16-page reprint free from Readers Service Dept, Product Engineering, 330 W 42nd St, NY 36, N.Y. —E J Tangerman

NO TEETH ON THESE RATCHETS

With springs, rollers and other devices they keep motion going one way.

L KASPER
design consultant
Philadelphia



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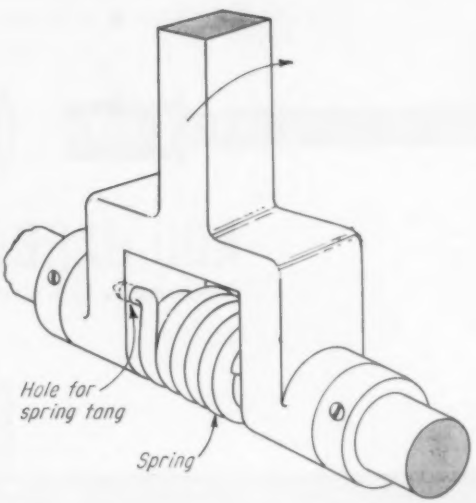

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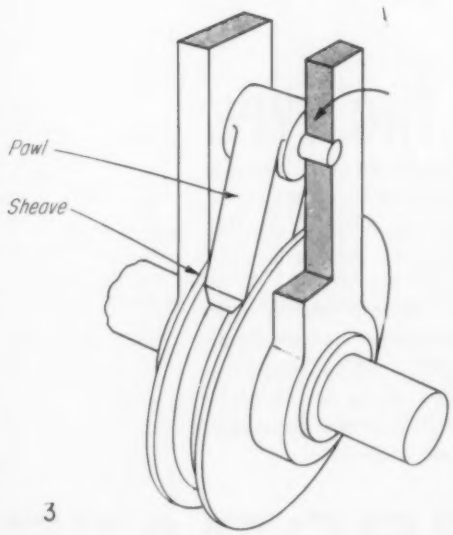

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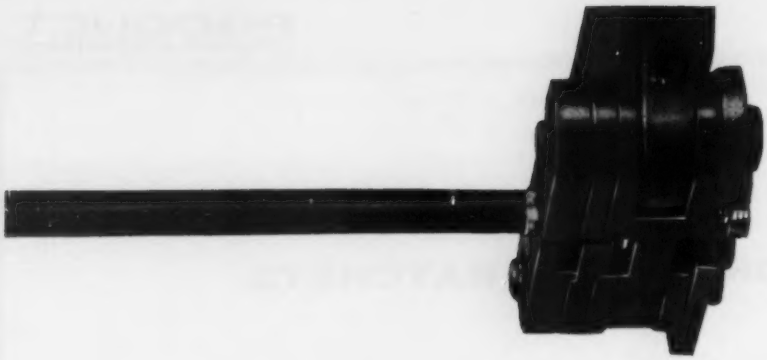
1 SWINGING PAWLS lock on rim when lever swings forward, and release on return stroke. Oversize holes for supporting stud make sure both top and bottom surfaces of pawls make contact.

2 HELICAL SPRING grips shaft because its inner diameter is smaller than the outer diameter of shaft. During forward stroke, spring winds tighter; during return stroke, it expands.

3 V-BELT SHEAVE is pushed around when pawl wedges in groove. For a snug fit, bottom of pawl is tapered like a V-belt.



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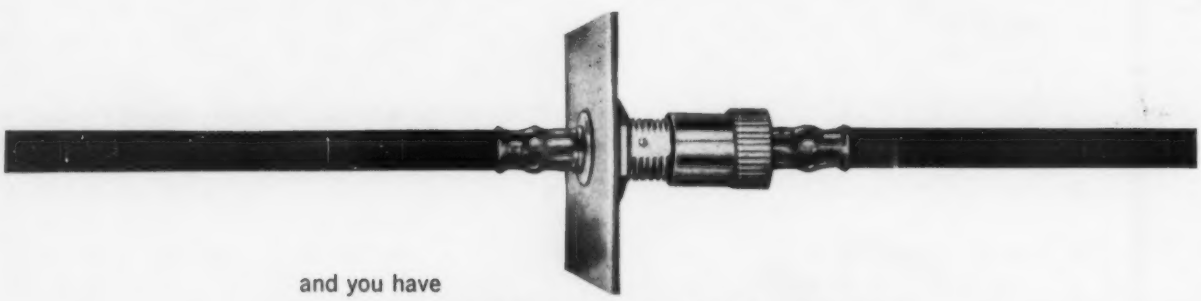
the only coaxial cable connector which attaches to both center conductor and outer braid with ONE CRIMP of the matching, precision-controlled crimping tool.

ADD HARDWARE

a lock nut, a lock washer and plug retaining unit.



and you have

AMP COAXICON TNC TYPE

the only threaded nut coaxial connector for through panel installations which can be attached to both inner conductor and outer braid with ONE CRIMP of the matching AMP tool.

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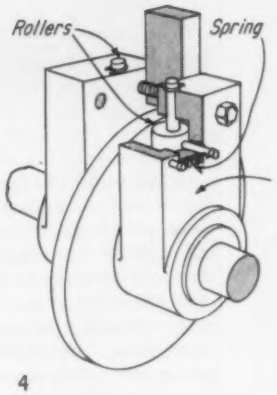

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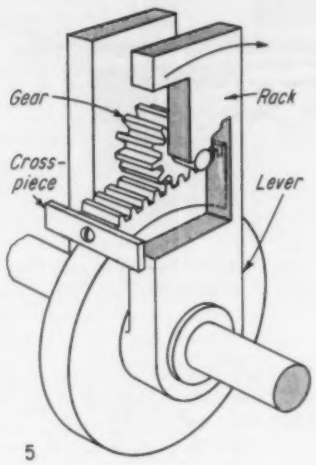

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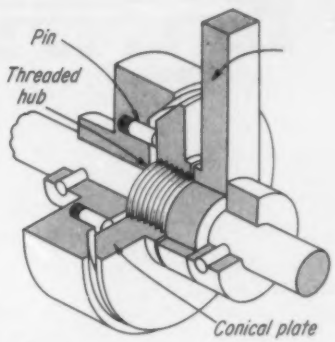

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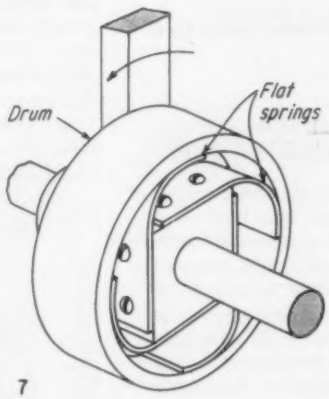

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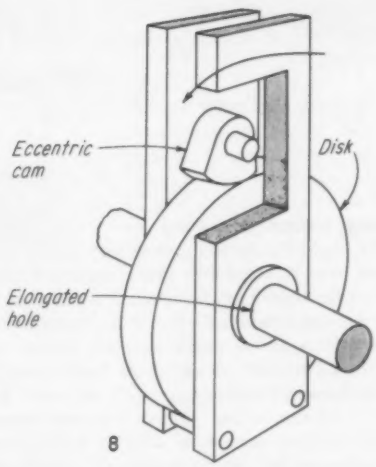

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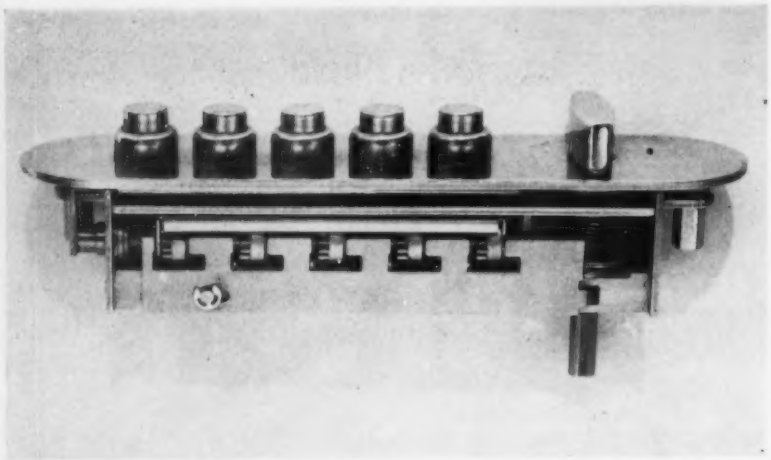
4 ECCENTRIC ROLLERS squeeze disk on forward stroke. On return stroke, rollers rotate backwards and release their grip. Springs keep rollers in contact with disk.

5 RACK is wedge-shape so that it jams between the rolling gear and the disk, pushing the shaft forward. When the driving lever makes its return stroke, it carries along the unattached rack by the crosspiece.

6 CONICAL PLATE moves as a nut back and forth along the threaded center hub of the lever. Light friction of spring-loaded pins keeps the plate from rotating with the hub.

7 FLAT SPRINGS expand against inside of drum when lever moves one way, but drag loosely when lever turns drum in opposite direction.

8 ECCENTRIC CAM jams against disk during motion half of cycle. Elongated holes in the levers allow cam to wedge itself more tightly in place.



Pushbutton lock . . .

consisting of 5 pushbuttons and a knob, handle or lever, provides thousands of combinations that can be reset in 6 sec without tools. Operated by fingertip alone, it is opened by pressing one or more buttons in prescribed order and turning knob to right. It is relocked by turning knob to left. Contains no tumblers that can be felt or sensed; thus, is impervious to tampering by pick-lock, X-ray, stethoscope or touch. Suitable for automobile doors, ignition switches, desks, filing cabinets, lockers, machine tools, vending machines and other industrial equipment (can be engineered to meet specific requirements). Measures $\frac{7}{8}$ x $\frac{7}{8}$ x $3\frac{3}{4}$ in. and is constructed of either heavily-plated steel or stainless steel. Priced at $4 to $5, with delivery in 6 wk. **Simplex Lock Corp, 150 Broadway, New York 38.**

Circle 300 on Reader Service Card

Pragramming timer . . .

combines a 115-v ac, 400-c, synchronous motor with a 28-v dc magnetic clutch to provide two or more fixed or adjustable timing sequences with automatic reset upon completion. Timer withstands 15-g shock and is sealed against environment. Measures $3\frac{3}{32}$ x $3\frac{3}{32}$ x $3\frac{1}{2}$ in. and weighs 2.75 lb. In a typical custom-built cycle, application of clutch power actuates a SPDT switch in 5 sec, ±0.25 sec, after motor is started. A second switch can be actuated at any point between 5 and 120 sec, depending upon setting of a screwdriver adjustment on unit's exterior. Repeatability of the adjustable time delay is ±3% of max setting. Motor stops automatically after actuation of second switch and both switches remain in actuated position until removal of the clutch power at which time unit is reset automatically to starting position. Switch rating is 4 amp resistive load at 28 v dc. Delivery in approx 12 wk. **Globe Industries Inc, 1784 Stanley Ave, Dayton 4, Ohio.**

Circle 301 on Reader Service Card

Solid-state switch . . .

produces no transients into the power line when it switches load off and on the line. There also are said to be no contacts to arc, spark or weld when changing the load. Input contacts use no current or voltage to actuate. Instead, only a resistive opening or closing of the contacts is required, and solid-state circuitry is such that it duplicates this condition in the load circuit. Suitable for use where all electrical noise must be eliminated, unit can switch load circuits of 20 amp at 115 v ac. Response time is said to be extremely fast since there are no moving parts. Measures 0.75 x 1.625 x 1.093 in. and weighs 2.5 oz. Available for 5-, 10- and 20-amp load circuits at 115 v ac. Delivery ranges from stock to 2 wk. **L J Products, 7464 Girard Ave, La Jolla, Calif.**

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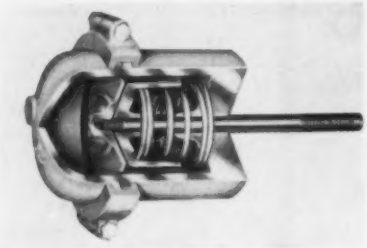
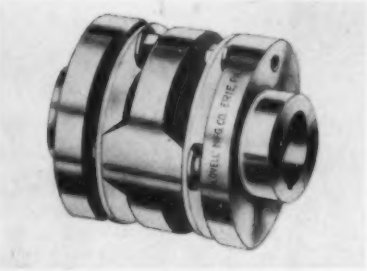


Rolling diaphragm actuator . . .

is air-operated unit that responds immediately to small changes in air pressure; has stroke up to 12 in.; and has smaller diameter piston than flat or convoluted diaphragm motors. Rolling diaphragm prevents loss of air between cylinder wall and piston, which do not touch. Because of this absence of metal-to-metal contact, there is no starting friction. Suitable for sliding stem operation of valves, rheostats, speed reducers, automatic air clamping mechanisms, automatic proportioning pumps and other equipment which can be controlled by a reciprocating motion. Available types include: air-to-close, spring to open (normally open); air-to-open, trapped air to close (normally closed); air-to-close with positioner (normally open); and air-to-open with positioner (normally closed). Each type comes in full range of sizes. Air-to-open types are furnished with a check valve and a 0-100 psi gage. Air-to-open types with positioners are furnished with pressure reducing valve, check valve and gage. From stock at $40 to $617. **RKL Controls Inc, Hainesport, NJ.**

Circle 303 on Reader Service Card

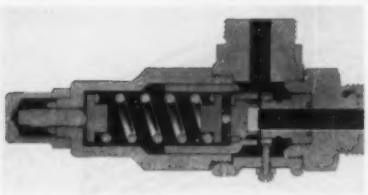


Flexing member coupling . . .

is designed around a non-metallic material, said to have an "ideal" modulus of elasticity and a flexural fatigue strength exceeding that of steel. Reportedly accommodates every combination of misalignment at all rated speeds with no drop in power transmitted. Requires no lubrication since there are no moving parts and has zero blacklash. Said to be smaller and lighter than other equally rated couplings. Available for shaft diameters of $\frac{1}{4}$ to $3\frac{1}{4}$ in.

and for hp requirements, at 100 rpm of 0.3 to 29. From stock at $5 to $150. **Flexible Coupling Div, Lovell Mfg Co, Erie, Penna.**

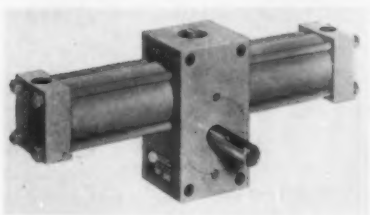
Circle 304 on Reader Service Card



Positive seating relief valve

combining a resilient, flat seated nylon disk with guided lift design, eliminates leakage caused by spring deflection and galling in metal-to-metal seated valves. Disk automatically compensates for any surface irregularities on metal seat and assures positive sealing over entire contact area until preset pressure is exceeded. Adjustable blowdown ring limits blowdown or pressure relief to within 10% of preset pressure. Available for pressure ranges of 300-1000 psi, 1000-3000 psi or 3000-5000 psi with ½- or ¾-in. end connection. Suitable for temperatures from −20 to 275 F. **Combination Pump Valve Co, 848 Preston St, Philadelphia 4.**

Circle 305 on Reader Service Card



Reversible rotary actuator . . .

driven by air or hydraulic fluid pressure, has two opposing pistons that move a gear rack over a pinion on a drive shaft for any desired rotation up to 360°. Rotation of the shaft may be stopped and reversed at any part of the cycle. Available in three models that develop 50 to 314 in.-lb torque with 100-psi pressure. Drive shaft is keyed for use with stock worm or spur gears or special cam or lever attachments. **Mo-Bar Hydraulics Co, Crystal Lake, Ill.**

Circle 306 on Reader Service Card

Concealed latch . . .

originally designed for enclosed lighting fixtures, is made so that light pressure at any point on an access panel releases panel instantly. Similar pressure closes panel with positive locking action. Single hold mounting with a common nut eliminates riveting, welding and special tooling for production line installation. Also can be mounted in castings with tapped holes. **Camloc Fastener Corp, 62 Spring Valley Rd, Paramus, NJ.**

Circle 307 on Reader Service Card

Differential pressure transducer . . .

is 2 x 1½ x 1⅝-in. unit for direct mounting on hydraulic actuators or related equipment. Potentiometer-type unit uses a spiral bourdon tube and special isolation bellows to give full complement of zero-centered pressure ranges with low error. Platinum alloy wire potentiometer element is matched to the bourdon tube to compensate for tube nonlinearities. Has static error band specification of 1.3%; range, ±400 to ±3500 psid; resistances, 1 k to 10 k ohm, ±5%; nominal resolution, 0.2 to 0.4%; response time, 15 millisec or less; and vibration, 35 gs. Can be adapted to male pressure tube fitting connectors. **Bourns Inc, 6135 Magnolia Ave, Riverside, Calif.**

Circle 308 on Reader Service Card

In-line filter . . .

has element which can be removed and replaced without removing the housing from the system. Element is type 316 sintered stainless steel to prevent flaking, thereby eliminating danger of downstream contamination. Various micron-size elements can be supplied. Large filtering area is said to minimize pressure drop and increase element life. Unit is available in brass and type 316 stainless steel with Buna-N or Vitron-A O-rings and rubber gaskets. **Nuclear Products Co, 15635 Saranac Rd, Cleveland 10.**

Circle 309 on Reader Service Card

Tough acrylic sheet . . .

is molecularly oriented to improve its resistance to cracking and crazing; reduce its notch sensitivity; and increase its tensile elongation before rupture. Can be punched or stamped to intricate shapes without cracking if proper techniques are used (stamping at 90 F with punch and die sets equipped with stripper plates is recommended). Although rigid, it is said to be highly flexible and can be readily cold formed to a radius only 60 times thickness. Also suitable as a glazing material. Available as colorless sheet in 42 x 42 and 84 x 84 in. sizes, 0.050 in. thick (sheets in color and in other thicknesses may soon be available). Priced at $.65 per sq ft. **Rohm & Haas, Plastics Sales Dept, Washington Square, Philadelphia 5.**

Circle 310 on Reader Service Card

Four-vane air pumps . . .

available in two models for use in vacuum, pressure or gas boosting operations, provide vacuum to 26 in. Hg, pressure to 13 psig and volumes from 12 to 54 cfm. Each has cast-iron housing and rotor with four sliding vanes which maintain contact with housing by centrifugal force. Equipped with anti-friction bearings, rotary mechanical shaft seals, inlet filter and automatic oiler. **Leiman Bros Inc, 102 Christie St, Newark 5, NJ.**

Circle 311 on Reader Service Card

Vacuum tube electronic timer

has SPDT plug-in relay output rated 5 amp and timing range from 0.06 to 120 sec with repetitive accuracy of ±2%. Permits infinitely variable time adjustments over entire range. Standard unit is 115 v, 50/60 c with SPDT contact arrangement. Initiating means is either momentary or maintained contact. From stock at $37. **Syracuse Electronics Corp, PO Box 566, Syracuse 1, NY.**

Circle 312 on Reader Service Card

Motor brakes . . .

are 1½ and 3 lb-ft torque units for direct shaft attachment to NEMA motor frames 56C, 66C, 182C and 184C. Use standard

continued on page 95

Sensitive DIFFERENTIAL PRESSURE and VACUUM CONTROLS

J6K J27KB

By using **UNITED ELECTRIC's** Type J6K or Type J27KB control, it is possible to control accurately the difference in pressure between two pressure or vacuum sources. The J6K contains a single switch; the J27KB is a dual switch control.

System Differential	Up to 90 psi.
Switch Differential	J6K — can be set between limits of ½" Hg and 3 psi. J27KB — can be set between limits of 1" Hg and 5 psi.
Switch Ratings	15 amps. at 115 or 230 volts A.C. Also 20 amps. or D.C. switches on specification.
Switch Types	N.O., N.C., or Double Throw — no neutral position.
Adjustments	J6K — internally located, uncalibrated adjustment wheel. J27KB — each switch has independent, uncalibrated adjustment screw.
Electrical Connections	Made to screw terminals on switches through clearance hole in enclosure.
Pressure Connections	Two ¼" female NPT pressure connections.
Size	J6K — 7 3/32" x 4 27/32" x 2 5/16". J27KB — 7 1/16" x 6 1/8" x 2 7/8".
Approximate Weight	J6K — 2¼ lbs. J27KB — 2 lbs.

***UNITED ELECTRIC** manufactures a complete line of temperature, pressure and vacuum controls. Standard units can be modified or custom-built units made to your specifications. Additional information on pressure and vacuum controls is available upon request.*

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CONTROLS COMPANY
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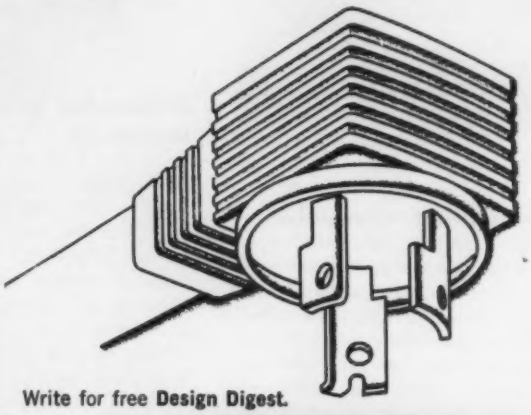

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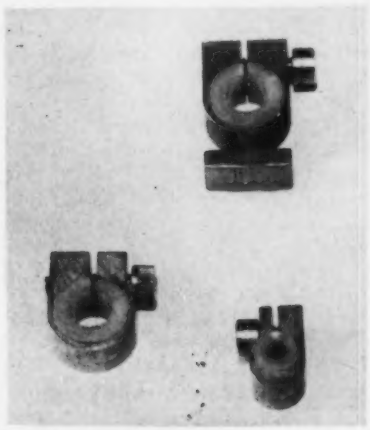
NEMA length shaft extension for hub mounting; knockout plug is provided for through-shaft accommodations. Units are electrically released and spring set. In event of power failure, they hold load until power is restored. External release trip permits remote operation. **Dings Brakes Inc, 4715 W Electric Ave, Milwaukee 46.**

Circle 313 on Reader Service Card

Bleed valve . . .

has 1½-in. dia, ¼-in. plate glass window through which liquid flow can be viewed. Suitable for closed-loop and high-volatile systems, the 1000-psi valve permits positive-check bleeding back to the system supply. Either drip or full flow bleeding is possible. **Industrial Mfg & Tool Co, 25519 John R, Madison Heights, Mich.**

Circle 314 on Reader Service Card



Nylon insert clamps . . .

are available in ⅛-, ¼- and $\frac{3}{16}$-in. shaft sizes and in balanced, unbalanced, gear, hinged, pull and swivel types. Made to ±0.001 tolerance and reportedly tend to flow into hub grooves, improving grip. Also said to produce uniform pressure and prevent marring of shafts and hubs. From stock at $1.95 and $3.25. **Sterling Precision Corp, Component Div, 5 Sintsink Dr, Port Washington, LI, NY.**

Circle 315 on Reader Service Card

Transistor-equipped timer . . .

employs a simple timing network with no moving parts or tubes to extend life up to 500 million operations. A filtered power supply working through a transistor operates a DPDT, make before break, mercury-wetted relay. Transistor is said to allow immediate operation, eliminating warmup time required by vacuum tube timers. Requires up to 50% less power than conventional electrome-

continued on page 96

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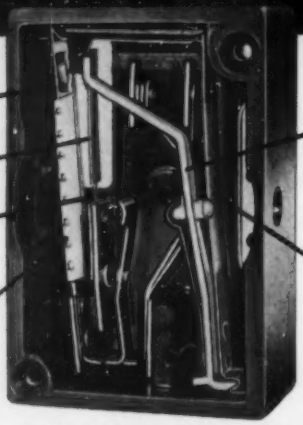

ARK-LES INFINITE CONTROL SWITCH

A PRODUCT OF: ARK-LES INFINITE CONTROLS, INC. WATERTOWN, MASSACHUSETTS

The ARK-LES Infinite Control Switch is a superb example of the word "infinite". In this application it means an infinite number of heat positions — giving a per cent control of full heat or full wattage regardless of cooking conditions.

To start the cycle, the knob is set at any position except "high". This moves the calibrating arm (A) to the right. The ambient compensating bimetal (B) connected to the arm, acts as a loading spring by transmitting force through the cross link to the main bimetal (C) causing the main bimetal contact to engage the contact on the auxiliary bimetal (D). When the main contacts engage each other, load current flows through the bimetals, causing them to increase in temperature. Main bimetal moves left. Auxiliary bimetal follows this movement, due to the fast-acting narrow bimetal strip (E) on the auxiliary bimetal assembly. Increasing temperature causes the main auxiliary bimetal to move right as the main bimetal is bending left. This effects a clean break. Open, the bimetals cool — the main bimetal much more slowly due to the heat control insulator (F). After a cooling period, both contacts are moving toward each other and the cycle is repeated.

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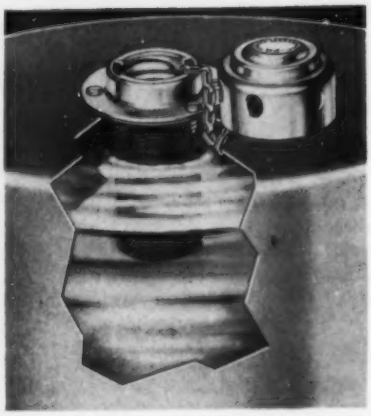
chanical timers—115 or 230 v, 50/60 c. Load contact rating is 5 amp at 115 v ac, non-inductive (should be arc-suppressed). **Automatic Timing & Controls Inc, King of Prussia, Penna.**

Circle 316 on Reader Service Card



Filler-air filter cap assembly

protects against particles as small as 40 microns. Vented, breather cap twist-locks on a close neck flange and is secured against loss by a chain fastened to the flange. Cap, flange and chain are cadmium-plated for protection against rust and corrosion. Strainer, made of 30 mesh brass wire screen, is 3 in. deep and 1 ⅛ in. dia. **Lenz Co, 3301 Klepinger Rd, Dayton 1, Ohio.**

Circle 317 on Reader Service Card

Subminiature time-delay relays

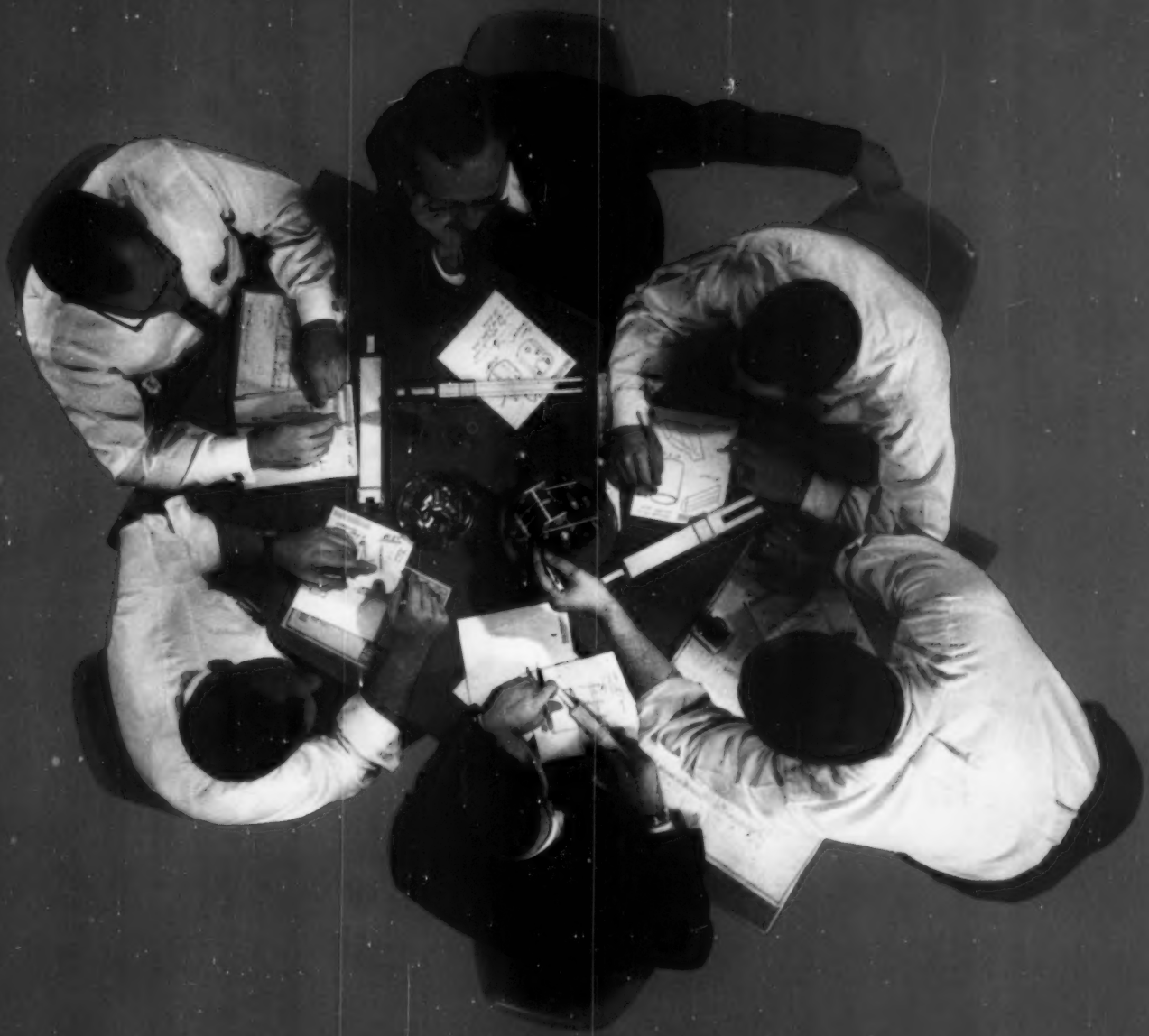
come in small cylinders for limited space applications. One multiple-output-contact model has operating delay range of 1 to 90 sec and accuracy of ±10%, 0.5 sec min. Another model is a voltage-compensated, instantly recycleable relay with an operating range of 15 to 300 sec. Available with either solder hook or plug-in headers and contain both a thermal delay unit and multiple contact magnetic relay. **Branson Corp, 41 S Jefferson Rd, Whippany, NJ.**

Circle 318 on Reader Service Card

Photoelectric scanner system . . .

requiring no tubes or transistors, provides positive response when the light beam is interrupted by objects as small as ¼ in. wide at counting rates up to 500 per min. Depending on light source and photocell used, operating ranges can be up to 8 ft. System comprises a 110-130 v, 50/60-c power unit, plug-in relay and choice of miniature or medium-range scanning heads. Uses a high infrared-sensitive photocell

continued on page 99



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with filter to operate the dc relay without need for amplifiers. The dc supply for the relay-coil circuit and ac supply for light source are contained in the 3 x 3¾ x 4-in. power unit. Relay is plastic-encased, plug-in unit with two sets of SPST load contacts (one normally open and one normally closed). Contacts are rated 8 amp, 115 ac, non-inductive. **Farmer Electric Products Co Inc, 2300 Washington St, Newton Lower Falls, Mass.**

Circle 319 on Reader Service Card

50-amp power relay . . .

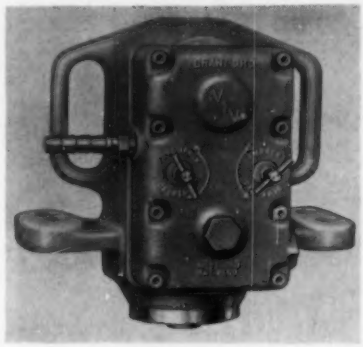
has special contact arms that provide positive contact wipe as contacts make and break. Contacts are SPST, normally open or normally closed, double break with heavy-duty silver alloy points. Unit also has heavy-duty armature hinge with stainless steel pin, assuring low friction for positive contact pressure and stable adjustment; fiberglass insulation; and one-piece stationary contact support and terminals. Measures 1⅞ x 1¹³⁄₁₆ x 1⅞ in. and weighs 3 oz. From stock with normally open contacts for 6, 12, 24 and 115 v ac and dc. Priced from $4.25 to $6.75 each. **Magnecraft Electric Co, 3350Y W Grand Ave, Chicago 51.**

Circle 320 on Reader Service Card

Through-bulkhead connector . . .

is hermetically sealed unit with pin-to-socket contact inserts. Suitable for use where an environmental seal must be maintained through a bulkhead, connector facilitaties checkout and maintenance since none of the wiring need be detached to break connection. When push-pull plugs mated with receptacle are disconnected, circuit is broken immediately. Insert design combines full compression glass on pin side and resilient silicone insert on socket contact side. Both inserts have positive contact identification in perfect correlation to plug inserts. In addition, extra thickness of the hermetic insert permits operation under extreme pressure loads. Connector is available in square flange, solder and hex nut mounting styles. Contact configurations of 3, 7, 12, 19, 27 and 37 combinations are offered. **Deutsch Co, Electronic Components Div, Municipal Airport, Banning, Calif.**

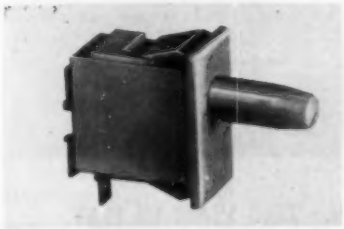
Circle 321 on Reader Service Card



Pneumatic vibrator . . .

is self-controllable, variable impact unit that can give changes of impact and frequency independently of each other or together. In addition to control of impact and frequency, unit offers ultra high impact amplitude. Having exceeded 20,000 g in acceleration tests, it is said to have kinetic energy of up to 10 times that of a conventional vibrator, yet consuming ⅛ to 1/50 the amount of air. Used for moving powdered or granular materials in bins and hoppers, where low frequency and high impacts are required and where low air consumption is an advantage. Frequency range is between 1 and 500 vibrations per min. Operates in any plane. From stock. **Branford Co, 132 Glen St, New Britain, Conn.**

Circle 322 on Reader Service Card



10-amp snap-action switch . . .

originally designed for manual or mechanical operation of vending machines, refrigerators and other appliances, require less than 1 cu in. of behind-panel space. Rated 10 amp at 250 v ac, ¼ hp at 125 v ac, the switch has standard SPDT contact arrangement (SPST optional). Also includes quick-connect terminals for easy wiring; integral nylon clips for front snap-in installation in panels 0.025 to 0.100 in. thick; and beryllium-copper, spring-operating fine silver contacts. Except for ex-

continued on page 100

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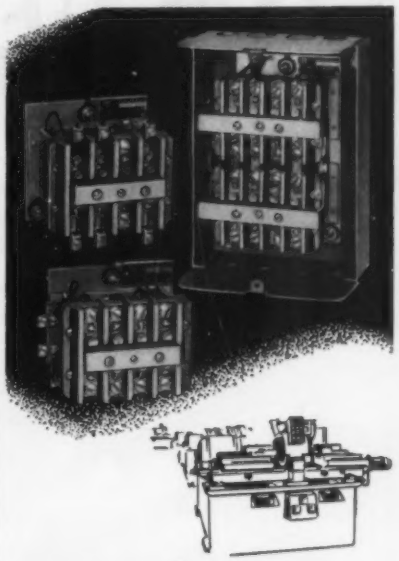
COMPACT CONTACTORS
for high capacity service!



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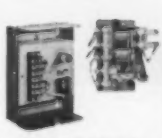
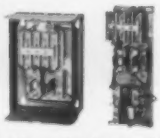


Induction Type & Electronic Relays



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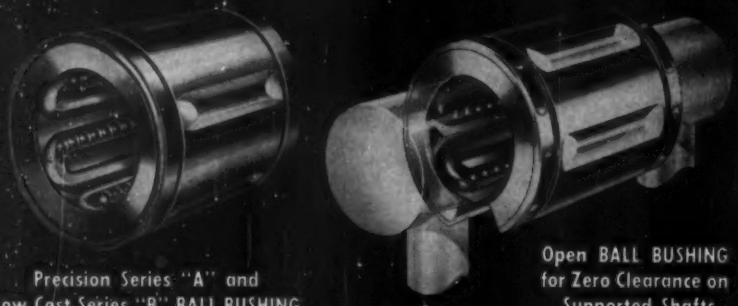

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Also Manufacturers of NYLINED Bearings . . . Sleeve Bearings of DuPont Nylon, and 60 CASE . . . Hardened and Ground Steel Shafting

posed terminals, unit is enclosed in white nylon housing. White nylon operating plunger has ¾-in. overtravel and ½-in. total travel. **Micro Switch Div, Minneapolis-Honeywell Regulator Co, Freeport, Ill.**

Circle 323 on Reader Service Card

Rectifier panel instruments

are 2½-, 3½- and 4½-in. models with voltmeters ratings of 10 to 300 and 10 to 150 v and ammeters ratings from 500 microamp to 20 milliamp. Use full-wave copper-oxide rectifiers and permit ac current measurement with only 20 to 25% as much resistance as ac moving iron instruments. Each meter has self-shielded core-maget mechanism. Also alloy ac voltage measurement with sensitivities of 100 ohm per v or better. Said to be particularly suitable for ac voltage measurement at frequencies up to 10,000 c or over a wide range of frequencies with very little sensitivity or error to the varying frequency. Scale lengths of the three models range from 2.1 to 3.9 in. **General Electric Co, Schenectady 5, NY.**

Circle 324 on Reader Service Card

Intake strainer-filter . . .

is said to offer twice, and, in some sizes, three times the filter area of other filters with same envelope size. Currently available in capacities of 5 to 10 gpm, 10 to 20 gpm and 20 to 30 gpm (larger capacities to come). Filters are supplied in standard 100 mesh (140 micron) and in 60, 80, 150 and 200 mesh for filtering particles from 260 to 75 microns. Wire mesh is made of Monel, while other parts are of cadmium-plated steel. **Michigan Wire Cloth Co, 2100 Howard St, Detroit 16.**

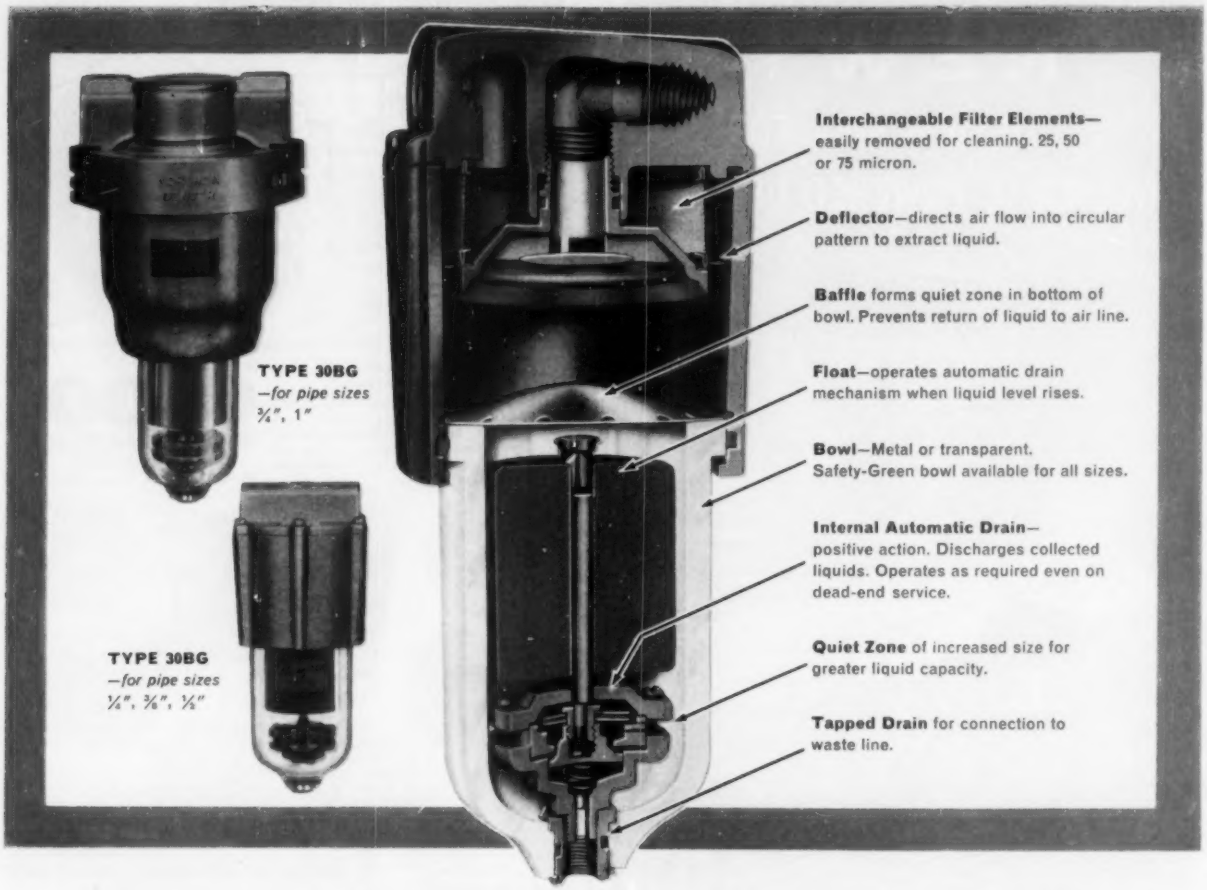
Circle 325 on Reader Service Card

Solid state relay . . .

"latches" in either position and holds "on" position when contact load is lost. Includes snap-action switching; pulse switching both "on" and "off"; polarity reversal protection; and "on-off" switch

continued on page 103

←CIRCLE 100 ON READER SERVICE CARD


TYPE 30BG
—for pipe sizes
¾", 1"
TYPE 30BG
—for pipe sizes
¼", ⅜", ½"
Interchangeable Filter Elements—easily removed for cleaning. 25, 50 or 75 micron.
Deflector—directs air flow into circular pattern to extract liquid.
Baffle forms quiet zone in bottom of bowl. Prevents return of liquid to air line.
Float—operates automatic drain mechanism when liquid level rises.
Bowl—Metal or transparent. Safety-Green bowl available for all sizes.
Internal Automatic Drain—positive action. Discharges collected liquids. Operates as required even on dead-end service.
Quiet Zone of increased size for greater liquid capacity.
Tapped Drain for connection to waste line.

Norgren Automatic-Drain Compressed-Air-Line Filters provide FULL-TIME protection

The purpose of a compressed-air-line filter is to remove liquids and solids from the air-stream so that they cannot clog, corrode or damage air-powered equipment. Your equipment needs this protection *full-time.*

Manual drain filters are often neglected . . . are not drained as often as they should be. When excess liquid collects in the bowl these filters no longer do the job. Liquid in the air-stream passes right on through to your air tools, cylinders and other air-operated equipment.

This cannot happen with Norgren Automatic-Drain Filters. They empty themselves as often as required . . . never get too full. Operation is determined entirely by the need for draining; and not, as with some makes, by changes in air pressure. Although an automatic-drain filter costs more than a manual drain filter, Norgren Automatic-Drain filters protect your air-powered equipment *full-time* day and night, year-in-year-out. They prevent costly wear and damage to your equipment and eliminate man-hour costs for manual draining.

Order Norgren Automatic-Drain Filters from your nearby Norgren Representative, listed in the telephone directory—or write factory for catalog.

FOUNDED IN 1925

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NEW!

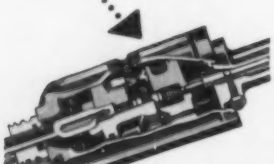
. . . DESIGN IDEA FOR PNEUMATIC POWERED DEVICES

. . . Put *Humphrey* *Cartridge Type Insert Valves* INSIDE YOUR PRODUCT

These Humphrey "Quick-Dump" Valves are installed by dropping them into a machined cavity, *inside* the cylinder, manifold, control handle, etc.

They save weight, cut material and component costs, reduce assembly time, speed up production. They eliminate the plumbing, permit installing multiple valves in small space, help simplify, miniaturize and clean up product design.

Choice of 2-way or 3-way, in ⅛" or ¼" sizes, for manual, electric or piloted operation. *Write for bulletin pictured below.*



Also — full line of conventionally mounted "Quick-Dump" Valves . . . manual, electric, piloted.

Humphrey PRODUCTS
Div. of General Gas Light Company
P.O. Box 2008, Kalamazoo, Michigan

New Home of Humphrey Products

NEW bulletin gives engineering data on Cartridge Valves

DO YOU HAVE THIS FILING PROBLEM ?

Odd-sized drawers, cabinets and pigeonholes robbing you of space!

Bulky filing units waste up to fifty per-cent of a room's filing space.

Com-PACK-t INTERLOCK FILES can be assembled in any width . . . any height. Fit in and around conventional type files, pillars, walls and heating and air conditioning units. *For additional details, write:*

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INTERLOCK FILING SYSTEM
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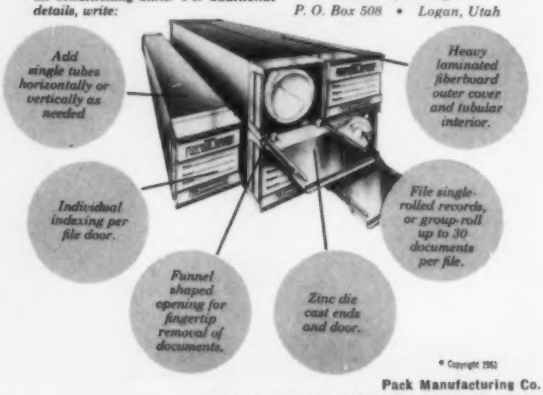
P. O. Box 508 • Logan, Utah


Add single tubes horizontally or vertically as needed
Heavy laminated fiberboard outer cover and tubular interior.
Individual indexing per file door.
File single-rolled records, or group-roll up to 30 documents per file.
Funnel shaped opening for fingertip removal of documents.
Zinc die cast ends and door.

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Pack Manufacturing Co.

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NOW-a "snap-in" rod wiper that really works!

This new, *non-metallic rod wiper* is made in *one piece* of Disogrin's polyurethane elastomer. It offers the outstanding resilience, "memory", abrasion and tear resistance proved in Disogrin "U" cups and "O" rings and in fork truck wheels. It is not affected by ozone and scrapes absolutely everything from the rod without scratching or marring.

Thus, this new scraper works – really works – even with pitted or scored shafts. Just snap it in and forget about it. Available in a complete range of sizes – Write for data and new Disogrin polyurethane seal catalogue.

DISOGRIN INDUSTRIES
A DIVISION OF PELLON CORP.

510 South Fulton Avenue
Mount Vernon, New York
Telephone:
MOunt Vernon 4-7733

CIRCLE 128 ON READER SERVICE CARD

points comparable to pull-in and drop-out points on electromechanical devices. Also uses heat-transfer technique for high contact current capabilities in small package. Performs under high vibration and shock up to 150 g's, 11 millisec and is said to have an operating life of 1 million cycles at full load. There reportedly is no contact bounce or arcing under load. Can be supplied with switching times as low as 22 microsec. Both ac and dc types are available in SPST and DPDT contact arrangements. Operating temps are from −65 to 160 F. Priced at $78.50 with delivery in 3 wk. **Autronics Corp, 180 N Vinedo Ave, Pasadena, Calif.**

Circle 326 on Reader Service Card

Flow restrictors . . .

and snubbers, used as gage protectors against surges and as shock dampers in lines and systems, are stocked for short delivery in ⅛- to ½-in. sizes and of 2- to 65-micron porosities. Include porous metal powder elements, accommodate range of viscosities and are constructed without moving parts. **Remm Co, 7955 Haskell Ave, Van Nuys, Calif.**

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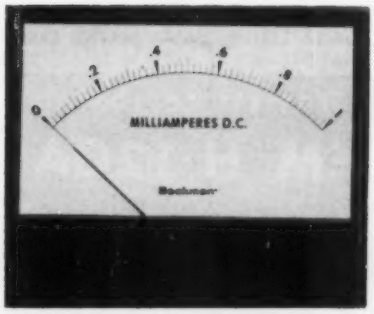


Rectangular panel meters . . .

each measuring approx 4.1 x 4.7 in., include 95 ac and dc voltmeters, ammeters, milliammeters and microammeters with bezel and all-metal construction. Have steel enclosures to protect movements from effects of magnetic fields and stray radio frequency; gasket seals to keep out dirt and moisture; and glass windows to eliminate errors caused by static charges. Scale length is a full 3.97 in. Standard accuracies are 2%. Delivery in 30 days on standard units; in 45 days on custom units. **Helipot Div, Beckman Instruments Inc, Fullerton, Calif.**

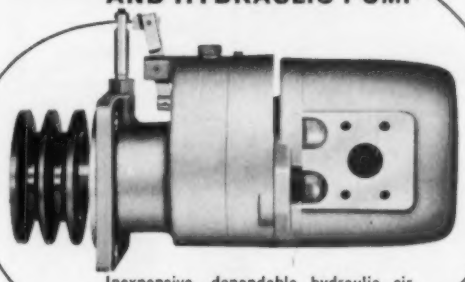
Circle 328 on Reader Service Card

Subminiature time delay relays . . .

are available as either delayed break after make or delay on make. Provide delay periods of from 0.025 to 180 sec and can

continued on page 105

BERRY
TOUCH-O-MATIC
REMOTE CONTROLLED
CLUTCH
AND HYDRAULIC PUMP



Inexpensive, dependable hydraulic circuit control for mobile equipment.

ELIMINATES NEED FOR PTO

Designed for belt, gear or direct drive

Engagement speeds from idle to 2200 RPM (no load speeds)

Flow rate: 1.7 to 26 GPM

H. P. output: ⅛ to 30 H. P.

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CIRCLE 103 ON READER SERVICE CARD

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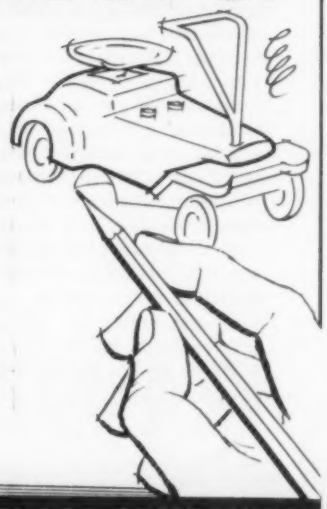
Tell us your problem; we'll help solve it with fiber glass reinforced plastic produced in matched metal dies. Call upon the experience and know-how of pioneers and specialists: Molded Fiber Glass.

Ask for free descriptive literature.



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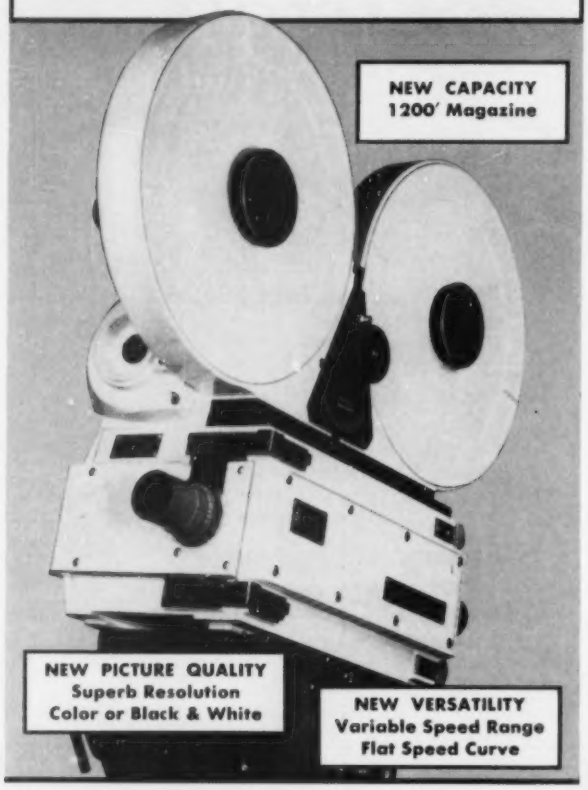
16mm High Speed Motion Picture Camera



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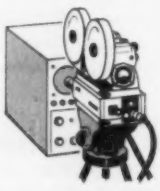
A high speed camera with large film capacity . . . with a variety of speed ranges and high resolution has long been wanted by industry, the military and the government. The FASTAX WF-30 fills all these requirements and more. Darkroom loaded, "T" core, the magazine holds sufficient film for most studies. Camera versatility is another key feature. Variable speed range, controlled by a solid state loop servo device . . . rapid acceleration with flat speed curve within ±4% selected rate . . . start-stop capabilities. Superb resolution over entire frame results from excellent lens system and a sector shutter between rotating prism and focal plane. WRITE for complete information and prices on WF-30 . . . the newest FASTAX in the wide line of Wollensak high speed motion picture cameras.



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Now—with the addition of a 316 stainless steel series—you have a Marsh Needle Valve for almost any purpose or service. Full range of sizes and patterns. Wide range of pressures and temperatures. All are machined from solid bar stock. All have precision ground stems for close regulation—tight shut-off. All have "Marpak" moulded packing; Teflon in stainless steel valves.

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Marsh Instrument & Valve Co. (Canada) Ltd., 8307 103rd St., Edmonton, Alberta, Canada. Houston Branch Plant 1121 Rockwell St., Sect. 15, Houston, Texas. Eastern Seaboard Warehouse: Marsh Instrument Company, 1208 Anderson Ave., Fort Lee, N. J.

ALLOY STEEL

316 STAINLESS STEEL

416 STAINLESS STEEL

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air dries . . . resists corrosion

HEAT-REM H-120A

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Heat-Rem H-120A is the ideal coating for temperatures up to 1200° F. It's easy to use . . . air dries without baking to an attractive hard aluminum coating in 6 hours . . . resists industrial fumes, most acids, salt spray and weathering.

Of extra heavy viscosity, H-120A is economical for either interior or exterior use. It is recommended for exhaust manifolds, mufflers, boilers, heat lines, pickling and boiling vats, etc.

Heat-Rem H-120A meets or exceeds government and industrial specifications. Brush, spray or dip application.

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$10.85 PER GALLON

SPECO, Inc.
"REM" PRODUCTS
Cleveland 9, Ohio

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CIRCLE 130 ON READER SERVICE CARD

be had as either fixed time or variable assemblies. Standard units are DPDT, 2.5 amp resistive with input voltage of 22 to 30 v dc. Withstand 100-g's shock for 11 millisec and vibration of 55 to 2000 cps at 30 g's. Timing intervals remain constant over wide range of environmental conditions. Encapsulated and provided with glass-sealed headers in enclosures measuring 1 $\frac{5}{16}$ x 1 $\frac{5}{16}$ x 1 in. Priced at $85 each with delivery from stock or within 2 wk. **Accutronics Inc, 403 N Foothill Rd, Beverly Hills, Calif.**

Circle 329 on Reader Service Card

Indicator valve . . .

has outside indicator, allowing the orifice position to be easily seen from a distance. Orifice can be set with high accuracy and locked with an optional handle. Threads are located outside valve packing and never come in contact with flowing medium, preventing corrosion and galling. Standard unit has O-ring packing, reducing interior "dead space" to a min, and comes in sizes $\frac{1}{4}$ to 4 in. with variety of standard tips (including needle point, V-groove and micro-flow) and seats for various flow requirements. Rated to 10,000 psi working pressure and available in either manual or air-actuated style. Prices start at $18. **Flow Systems Inc, 413 Poinsettia St, PO Box 444, Corona Del Mar, Calif.**

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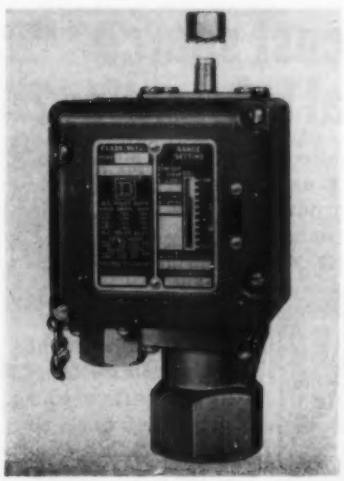

Hydraulic pressure switch . . .

is adjustable from 2000 to 15,000 psi on rising pressure. Has oil-tight construction and either 1- or 2-pole snap switch. Capable of operating rates up to 300 cycles per min. Strain relief provision prevents damage from shock on violent pressure surges. **Square D Co, Bingham Rd, Asheville, NC.**

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Design Uniform lift into equipment with DUFF-NORTON WORM GEAR JACKS

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for **AD 66DD.**

DUFF-NORTON COMPANY

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DUFF-NORTON JACKS
Ratchet • Screw
Hydraulic • Worm Gear

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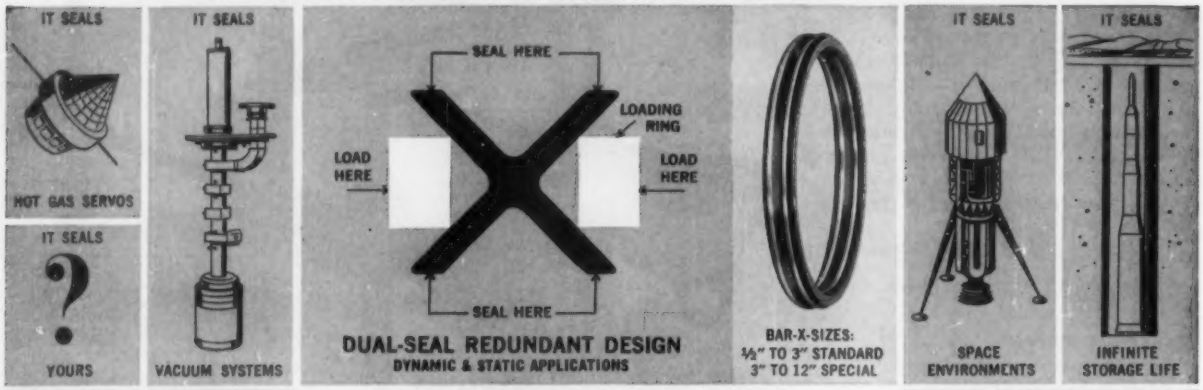
ANY FLUID—GAS—FUELS—WATER—LIQUID METALS—CRYOGENIC FLUIDS—CORROSIVE FLUIDS
ANY SYSTEM—HYDRAULIC—PNEUMATIC—VACUUM—CRYOGENIC—NUCLEAR



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UNPRECEDENTED SERVICE LIFE

Eliminates critical downtime ■ Very high and very low pressure ■ Easy, foolproof installation (not a mechanism) ■ All-metal—non-contaminating ■ Stable, symmetrical design

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Models, one ton and up. Can be driven by motors or manually operated . . . synchronized by interlocking shafting and gear boxes. Various screw attachment heads available . . . also stainless steel or hollow screws.
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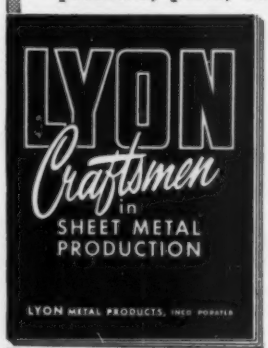

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CIRCLE 132 ON READER SERVICE CARD

DESIGN LITERATURE

Theory of Hydrodynamic Lubrication

OSCAR PINCUS and BENO STERNLIGHT. McGraw-Hill Book Co, Inc, 330 W 42 St., NY 36. 6 x 9, 465 pp. $15.00

This is a comprehensive, unified treatment of hydrodynamic and hydrostatic lubrication that emphasizes fundamentals basic to a wide range of design problems and applications.

It offers a formulation of the differential equations of lubrication (including energy and elasticity considerations) and presents techniques for solving these equations either analytically or by means of analog and digital computers. The book gives exact or approximate solutions of the differential equations involved and provides a basis for the design and the solution of specific bearing problems.

Special topics are presented for the first time to provide a keener insight into the theory of hydrodynamic lubrication such as hydrodynamic instability, hydrodynamics of rolling elements, inertia and turbulence effects, non-Newtonian fluids, and an extension of the classical theory.

There is an analysis of dynamically loaded bearings which reduces the steady-state solutions as only a limiting case, as well as analyses for finite journal and thrust bearings, energy considerations, elasticity, and compressible fluid and thrust bearings.

Other typical coverage includes basic differential equations, incompressible lubrication, gas bearings, hydrostatic bearings, squeeze films, dynamic loading, and variable viscosity. In addition, outstanding experiments which support the theory have been included to provide a link between theory and practice and to insure a clearer comprehension of the subject matter.

Introduction to Digital Computers

BERT F. GREEN, JR. PB 171100. Office of Technical Services, Dept of Commerce, Washington 25, DC. Paperbound, 8 x 10½, 26 pp. $1.25

This brief introduction to computers was prepared for psychologists but it can also serve as a first look for the uninitiated engineer. Like other papers of this kind, the authors begin by separating the digital computer from the analog machine and further subdividing this into special purpose digital computers, general purpose digital computers and specific machines such as the IBM 705 and 650, the Univac Scientific and the Royal McBee LGP-30. Most of the discussion is devoted to programming, how it is done and what the automatic programming routines do. There is no attempt to explain how the machine works. The appendix lists professional and trade journals in the computer field and a bibliography of books and articles.

Other Books of Interest

Tensile and Compressive Creep of 6Al-4V Titanium-alloy Sheet and Methods for Estimating the Minimum Creep Rate

NASA TN D-805, H L Price, G J Heimerl. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8 x 10¼, 19 pp. 50¢.

Analysis of Effective Thermal Conductivities of Honeycomb-core and Corrugated-core Sandwich Panels

NASA TN D-714, R T Swann, C M Pittman. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8 x 10¼, 62 pp. $1.75.

Local Buckling of Longitudinally Stiffened Curved Plates

NASA TN D-750, J P Peterson, R O Whitley. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8 x 10¼, 20 pp. 50¢.

ABSTRACTS FROM THE LITERATURE

Magnetic Malleable Irons

Standard or ferritic malleable iron is satisfactory for use as a cast, soft magnetic material. It is made by heat-treating white iron. In addition to its magnetic properties, it can be readily cast into intricate shapes and is one of the most machinable ferrous metals. By merely changing the heat-treatment, pearlitic or martensitic malleable iron can be produced from the same white iron.

Like all soft, magnetic materials, ferritic malleable iron is mechanically soft. On the other hand, pearlitic malleable and martensitic malleable irons are graphitic steels and exhibit a range of hardness and strength. They have the same availability as ferritic malleable and much of its machinability. Ordinarily, carbon steels are not used for magnetic applications, but because the pearlitic and

continued on page 109

GEARED to the FUTURE
SPUR GEARS AND PINIONS
3 to 24 diametral pitch, iron and steel.
BEVEL GEARS AND PINIONS
3 to 16 diametral pitch, iron and steel.
MITER GEARS
4 to 16 diametral pitch, iron and steel.
WORM GEARS AND WORMS
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CIRCLE 107 ON READER SERVICE CARD 107

THE KEY TO YOUR SECURITY DESIGN PROBLEM

If the equipment or product you are designing should have a lock, it should have the unique Chicago ACE® Lock. The above key fits the circular keyway of an ACE lock and is as symbolic of maximum security as it is different from conventional keys.

Because of the intricate tumbler combinations possible in a Chicago ACE Lock, you can specify your own registered, unduplicated key cut with duplicate keys available from the factory only.

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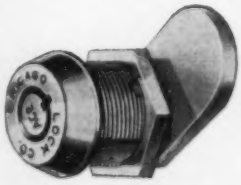

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LIVERMONT
TORQUE-LIMITING SCREWDRIVERS
FOR PRECISE TORQUE CONTROL

MODEL CAL-30

Model CAL-30 meets requirements of MIL-H-26497. Calibrations are clearly marked and magnified, for quick, easy reading. Disappearing thumb screw permits quick change of torque. (Torque setting can be sealed for production use.)

(capacity: 2 to 30 inch pounds)

MODEL PM-5

The Livermont PM-5 screwdriver is designed for electronic, and similar precision assembly work where extreme torque accuracy is required. Indicates for both left and right hand threads, and will accurately, safely, tighten the most fragile fastener, of metal or plastic.

NOTE: FAR EXCEEDS ACCURACY REQUIREMENTS OF MIL-H-26497

(capacity: 4 to 80 inch ounces)

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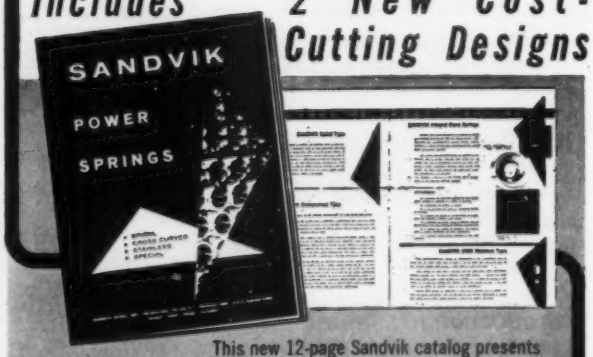

This new 12-page Sandvik catalog presents two completely new types of springs which give better performance and lower handling and installation costs.

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martensitic malleables have the advantages outlined above, there is some idea that they might be used as a compromise by giving up some magnetic quality to gain mechanical properties. This paper supplies the magnetic properties necessary for such compromise.

Magnetically, pearlitic and martensitic malleables behave like steels if allowance is made for the graphite which is present.

"Magnetic Properties of Malleable Irons," by W. K. Bock, director of research, National Malleable and Steel Castings Co, Cleveland. Transactions of the ASME Journal of Engineering for Industry, Paper No. 60-WA-218. American Society of Mechanical Engineers, 29 W 39 St, NY 18.

Anodes for Cathodic Protection

Data for calculating anode resistance to earth is presented. Recommendations are made for installing anodes for various soil conditions. Advantages are given for deep ground beds in high resistivity soil and in urban areas. Use of lead alloy and platinum anodes for underwater use is mentioned.

"Impressed Current Anodes for Cathodic Protection," by Walter P. Noser, senior corrosion engineer, Humble Pipe Line Co, Houston, Texas, Corrosion, Dec 1960, National Assn of Corrosion Engineers, 1061 M & M Bldg, Houston 2.

Controlling Dc Motors

This discussion covers the fundamental speed, torque, and horsepower relationships for dc motors. A client summarizes the 12 control circuits that form the basis of most of the packaged dc drives available today.

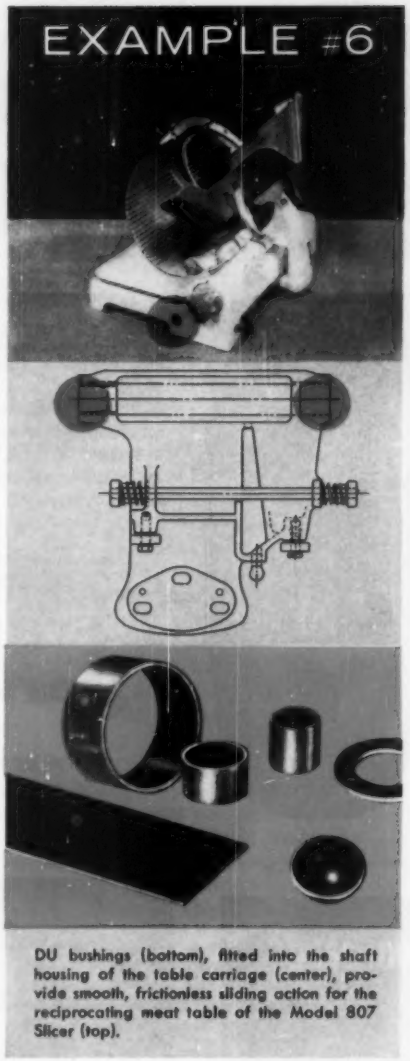
"Speed Control Methods for Dc Motors," by C. S. Siskind, Purdue University, Control Engineering, June 1960, 330 W 42nd St, NY 36.

Residual Molding Stresses

In molding thermosetting materials, normal design criteria and specifications are intensified whenever metallic inserts are included in the part. Over the years selection of these criteria and specifications has become commonplace, and a core of empirical knowledge is now available to experienced molders and designers.

Frequently, however, some design or material precautions taken by molders to avoid cracking are either superfluous or meet with little success. In the latter case, post baking or annealing of the parts is frequently per-

continued on page 111



DU bushings (bottom), fitted into the shaft housing of the table carriage (center), provide smooth, frictionless sliding action for the reciprocating meat table of the Model 807 Slicer (top).

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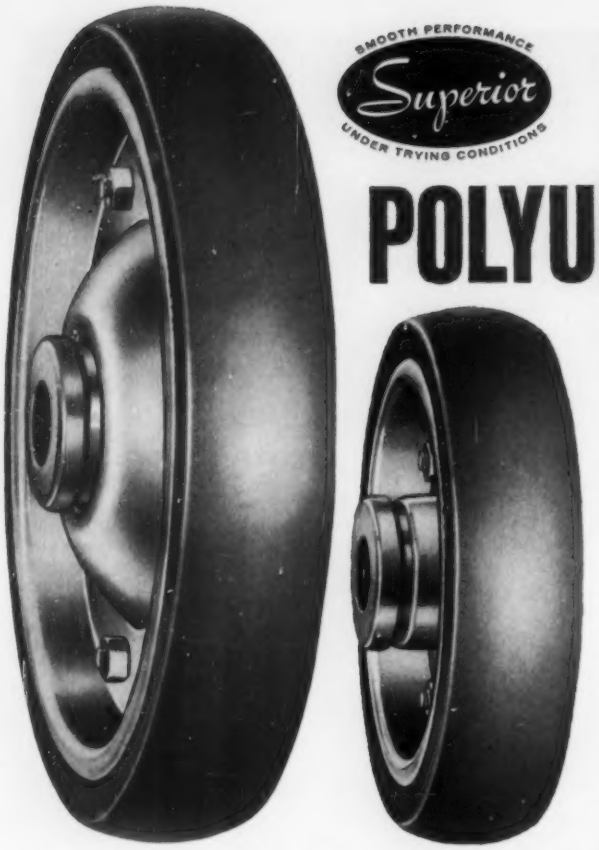

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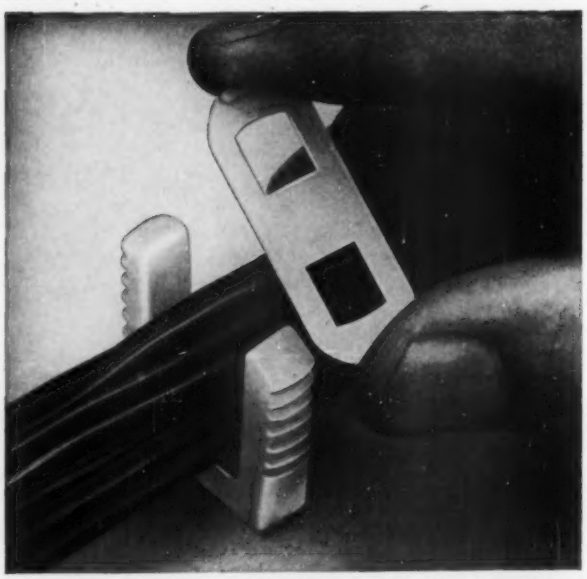

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formed. Reliable evaluation of such a procedure insures that sufficient reduction of residual stresses has been obtained to prevent excessive cracking in usage.

"Determination of The Effect of Annealing on Residual Holding-Stresses," by L. B. Allen, International Business Machines Corp, SPE Journal, July 1960, Society of Plastics Engineers, 65 Prospect St, Stamford, Conn.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 119.

POWER CYLINDERS—Bulletin AJH-104S, 32 pp. Contains size, thrust, bore, stroke and mounting data on complete line of air and hydraulic cylinders. Also supplies tables covering piston, piston rod and tie-rod torque; column strength, rod deflections, acceleration, safety factors, pressure losses in pipe, cylinder forces, etc. Cutaways and dimension drawings are included. Miller Fluid Power Div, Flick-Reedy Corp, 7N015 York Rd, Bensenville, Ill.

Circle 350 on Reader Service Card

GASKET MATERIALS—Booklet AD-109, 24 pp. Reviews all specifications, including resistance ratings, of homogeneous rubber, cloth-inserted rubber, asbestos and vegetable fiber gasket materials. Also carries procedures and formulas for designing a gasket, as well as common faults in gasket design and suggested remedies. Garlock Inc, Palmyra, NY.

Circle 351 on Reader Service Card

SILICONE RUBBER PRODUCTS—Bulletin S901a, 12 pp. Discusses silicone rubber's advantages, uses, physical properties and specific products, including sponge and sheet, roll coverings, conveyor belting, extruded tubings and shapes for gaskets and seals, hose and tubings for liquids, chemicals, etc. and molded goods. Hewitt-Robins, Dept SI, Stamford, Conn.

Circle 352 on Reader Service Card

POTENTIOMETERS—Data sheet series, 5 pp. Describe and illustrate sine-cosine, megohm, translatory, protractor and other linear and nonlinear types. Electrical specifications and power rating curves are given for several units. Accuracy Inc, 4 Gordon St, Waltham 54, Mass.

Circle 353 on Reader Service Card

RUBBER SHEET PACKING—Brochure PK-170A, 4 pp. Covers general purpose, diaphragm, neoprene and Nitrile sheet styles. Construction, recommended applications, ASTM and MIL specifications, durometer hardness, and temperature and pressure services are outlined for each. Available widths, approx weights and forms of packaging are tabulated. Johns-Manville, Packing Materials Div, 22 E 40th St, New York 16.

Circle 354 on Reader Service Card

V-BAND COUPLING—Pocket size bulletin WB-1, 8 pp. Explains how simplified fastening can improve functional design and product appearance, decrease assembly time and cut manufacturing costs. Also illustrates several available coupling and flange configurations, explains sealing principle and shows typical V-band applications. Marman Div, Aeroquip Corp, 11214 Exposition Blvd, Los Angeles.

Circle 355 on Reader Service Card

SHAFT POSITION ENCODER—Bulletin 041, 4 pp. Illustrates and outlines mechanical and electrical specifications of 11-digit unit that converts angular shaft displacement into electrical signals for digital readout. Outline drawings are included. AR&T Electronics Inc, 1101 McAlmont St, PO Box 627, Little Rock, Ark.

Circle 356 on Reader Service Card

POSITIVE-DISPLACEMENT PUMPS—Bulletin 91048, 6 pp. Supplies specifications, design features and dimensions of adjustable and non-adjustable models for metering, injecting, sampling, feeding, mixing or lubricating. Includes schematic drawings. Airmatic Valve Inc, 7313 Associate Ave, Cleveland 9.

Circle 357 on Reader Service Card

MINIATURIZED PRESSURE POTENTIOMETERS—Bulletin 1045, 4 pp. Reviews performance, case design, operating safety, calibration, and technical characteristics of two models that cover range of 0-10 to 0-5000 psia. Trans-Sonics Inc, PO Box 328, Lexington 73, Mass.

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continued on page 113

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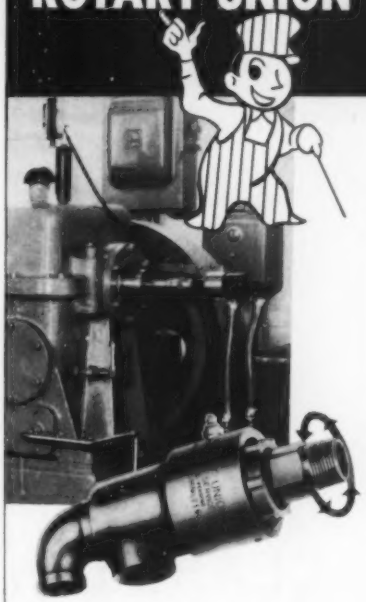

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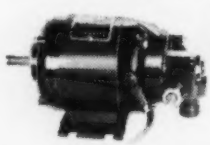

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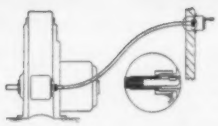

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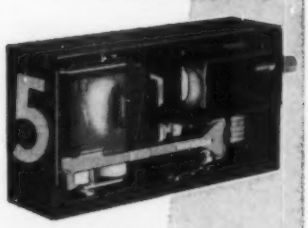

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DESIGN LITERATURE

CAST IRON FOOTSWITCHES—Bulletin GEA-7086A, 4 pp. Covers 5 types, 14 forms, giving stages, contact arrangements, pedal operation and ratings. Diagrams show contact operation. General Electric Co, Schenectady 5, NY.

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URETHANE FOAM PROTECTION—Booklet, 20 pp. Discusses molding in place, contouring advantages and other properties of urethane as they relate to industrial packaging problems. Mobay Chemical Co, Pittsburgh 5.

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SOUND, VIBRATION ELIMINATOR—Catalog 890, 4 pp. Reviews performance, applications, construction features, sizes and permissible movement in wire-reinforced, wrapped-fabric rubber pipe. Also compares acoustical impedances of the rubber unit with steel, copper, cast iron, lead, glass, concrete, water, pine and cork. General Rubber Corp, 70 Summit St, Tenafly, NJ.

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PORTABLE ELECTRICAL TESTERS—Bulletin Z-54, 8 pp. Lists models, accuracies, ranges, features and prices of such test units as matched ac and dc industrial meters, ac clamp voltammeters, ohmmeters and volt-ohm milliammeters. Photos of each are supplied. Daystrom Inc, Weston Instruments Div, 614 Frelinghuysen Ave, Newark, NJ.

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INDICATING TEMPERATURE CONTROLS—Catalog sheet 56, 2 pp. Applications, construction features and control ranges are given for hi-temp (0 to 1000 F) unit and low-cost short range unit. Outline drawings are included, as well as tables covering calibration, min on-off differential and thermal assembly data. United Electric Controls Co, 85 School St, Watertown 72, Mass.

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STRAIN RELIEFS—Bulletin, 4 pp. Describes and illustrates all-metal, click-on and insulated types for protecting cables or conductors. Installation of each type is sketched and sizes are listed. George Walker Co, Passaic, NJ.

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AUTOMATION ACCESSORIES—Catalog 101A, 4 pp. Presents dimensions, mounting requirements, electrical specifications and prices of electric vibrators and vibratory pedestal drivers. Automatic Feeder Co, 4752 W Washington Blvd, Chicago 44.

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continued on page 114

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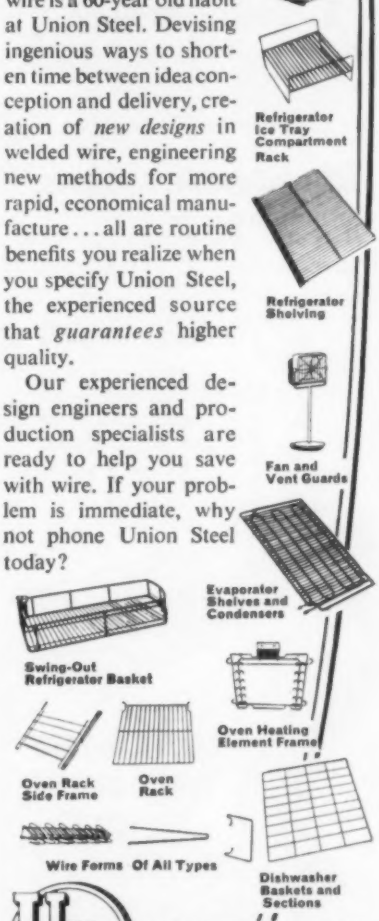

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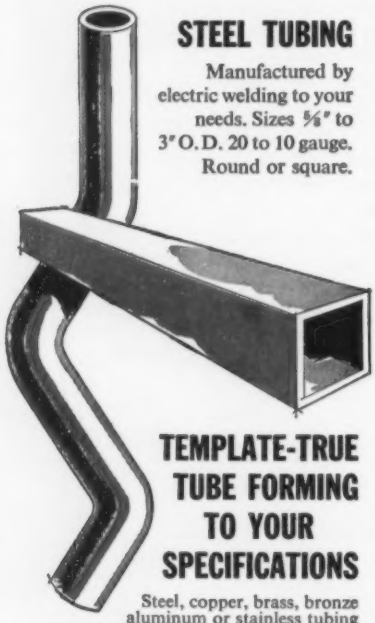

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MOTOR-PUMP UNITS—Bulletin 150.7, 4 pp. Carries specifications, dimension drawings, parts lists and a rating chart for 13 sizes. Also details units' "progressing cavity" principle that permits handling of abrasives and relatively large particles in suspension. Moyno Pump Div, Robbins & Myers Inc, Springfield, Ohio.

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PNEUMATIC FLOW TRANSMITTER—Data sheet 281-01.201-1, 4 pp. Traces performance characteristics and specifications of mercury-operated unit. Schematics show basic mechanism and typical installation with differential producer. Dimension drawings also are supplied. B-I-F Industries, PO Box 276, Providence 1, RI.

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MINIATURE RHEOSTAT—Bulletin H-125-561, 2 pp. Tabulates specifications and resistance values of unit that dissipates 12½ w although smaller than many low-wattage potentiometers. Includes dimension drawings. Hardwick, Hindle Inc, 40 Hermon St, Newark 5, NJ.

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PHOTOELECTRIC TACHOMETER—Bulletin, 2 pp. Traces specifications of three models covering speed ranges from less than 100 to 24,000 rpm. Also discusses design and operation, applications, maintenance and calibration. Simonds Worden White Co, 1101 Negley Pl, Dayton 7, Ohio.

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HIGH-STRENGTH FASTENER RELIABILITY—Report 495, 16 pp. Analyzes aircraft and missile bolt failures to build case for greater mechanical reliability in high-strength fastenings. Consists of data on 10 actual failures, either in flight, on test stand or in preliminary quality control testing with recommendations for correct-

continued on page 117

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VALVE SHOWN ACTUAL SIZE

VITAL STATISTICS

Type	3-way normally closed
Over-all size	1" x 2 1/16"
Orifice size	3/64" Inlet and Outlet
C_v factor	.045
Fluid connections	1/16" PTF (adapted for 1/8" tubing)
Weight	5 oz.
Maximum operating pressure	150 PSI
Vacuum	Down to 5 microns

Skinner Distributors are now stocking the first of these new valves—the three-way normally closed. Three-way normally open and directional control, two-way normally open and normally closed, and higher pressure models will be on the market soon.

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- Now designers of pneumatic and hydraulic control systems and devices requiring high flow in smaller packages can **specify miniature solenoid valves from shelf stock.**
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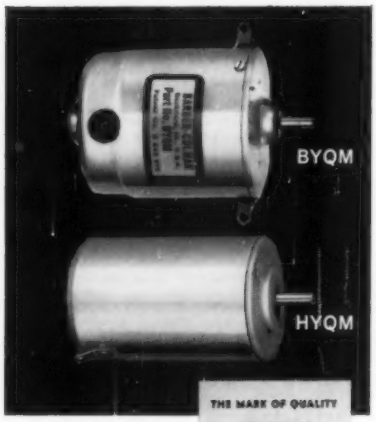

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Diameter	1.29"

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Voltage range	4.5 to 30 volts
Governed speed	1500 to 5000 rpm
Torque	0 to .20 oz-in.
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DRAFTING FURNITURE—Bulletin, 4 pp. Provides specifications of 25 models in three basic groups: drafting table and reference desk ensemble, single unit drafting desk and drafting desk with integral drawer unit. Construction features are detailed. Stacor Equipment Co, 295 Emmet St, Newark 5, NJ.

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ELECTRICAL CONTACTS—First issue, Confacts, bimonthly tech journal. Discussion of outboard motors is lead article of periodical to deal with latest techniques in use and fabrication of electrical contacts and contact assemblies. Publications Dept, Fansteel Metallurgical Corp, North Chicago, Ill.

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continued on page 119

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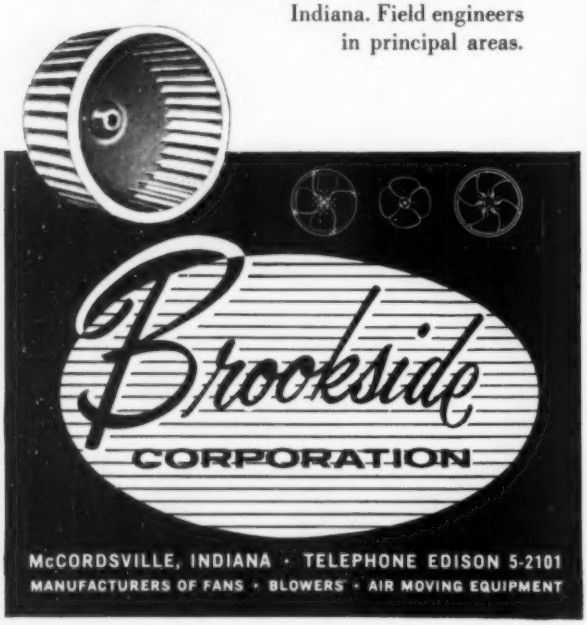
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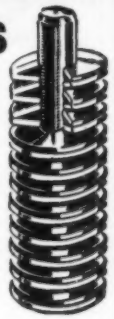

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PANEL INSTRUMENTS–Bulletin 01-113, 6 pp. Provides specifications of 4½-, 5½- and 7½-in.-size ac and dc ammeters, milliammeters, microammeters and voltmeters. Daystrom Inc, Weston Instruments Div, 614 Frelinghuysen Ave, Newark 12, NJ.
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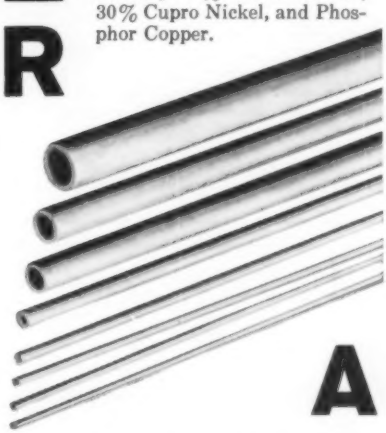

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21	44	67	90	113	136	159	306	329	352	375	398	
22	45	68	91	114	137	160	307	330	353	376	399	
23	46	69	92	115	138	161	308	331	354	377	400	

MAJOR PRODUCT MANUFACTURED

- ☐ Agricultural Equipment
- ☐ Aircraft, Missiles, Rockets
- ☐ Appliances, Radio, TV
- ☐ Auto, RR, Trans. Equip.
- ☐ Business & Commercial Machines
- ☐ Construction, Mining Equip.
- ☐ Elect. Machinery & Apparatus
- ☐ Industrial Machinery & Equip.
- ☐ Instruments & Scientific Equip.
- ☐ Ordnance & Accessories
- ☐ Other Fabricated Metal Pdts.

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Home ☐_____

Address Office ☐_____

City_____ Zone_____ State_____

Company Name_____ Your Dept._____

Products Mfgd. or Designed_____

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- ☐ Research & Development Engineering
- ☐ Manufacturing
- ☐ Administrative Engineering
- ☐ Company Management

Other_____

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NON-METALLIC MATERIALS, FINISHES
310—Tough Acrylic Sheet

POWER TRANSMISSION
304—Flexing Member Coupling
313—Motor Brakes

MECHANICAL PARTS
300—Pushbutton Lock

FASTENING AND JOINING
307—Concealed Latch
315—Nylon Insert Clamps

MOTORS, ENGINES AND CONTROLS
301—Programming Timer
303—Rolling Diaphragm Actuator
306—Reversible Rotary Actuator
313—Motor Brakes

ELECTRICAL, ELECTRONIC COMPONENTS
301—Programming Timer
302—Solid State Switch
308—Differential Pressure Transducer
312—Vacuum Tube Electronic Timer
316—Transistor-equipped Timer
318—Subminiature Time Delay Relays
319—Photoelectric Scanner System
320—50-amp Power Relay
321—Through-bulkhead Connector
323—10-amp Snap-action Switch
324—Rectifier Panel Instruments
326—Solid State Relay
328—Rectangular Panel Meters
329—Subminiature Time Delay Relays
331—Hydraulic Pressure Switch

HYDRAULIC, PNEUMATIC EQUIPMENT
303—Rolling Diaphragm Actuator
305—Positive Seating Relief Valve
306—Reversible Rotary Actuator
308—Differential Pressure Transducer
309—In-line Filter
311—Four-vane Air Pumps
314—Bleed Valve
317—Filler-air Filter Cap Assembly
322—Pneumatic Vibrator
325—Intake Strainer-Filter
327—Flow Restrictors
330—Indicator Valve
331—Hydraulic Pressure Switch

NEW CATALOGS AND BULLETINS

GENERAL ENGINEERING
371—Drafting Furniture, 4 pp, Stacor Equipment Co

METALS AND ALLOYS
376—Aluminum Casting Alloys, 8 pp, William F. Jobbins Inc

NON-METALLIC MATERIALS, FINISHES
351—Gasket Materials, 24 pp, Garlock Inc
352—Silicone Rubber Products, 12 pp, Hewitt-Robins
354—Rubber Sheet Packing, 4 pp, Johns-Manville, Packing Materials Div
360—Urethane Foam Protection, 20 pp, Mobay Chemical Co
373—Thermoplastic Materials, 28 pp, Conneaut Rubber & Plastics Co
378—Polycarbonate Films, 13 pp, Chemical Materials Dept, General Electric Co
379—Pressure-sensitive Tapes, 44 pp, Mystik Adhesive Products Inc

POWER TRANSMISSION
355—V-band Coupling, 8 pp, Marman Div, Aeroquip Corp
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351—Gasket Materials, 24 pp, Garlock Inc

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370—High-strength Fastener Reliability, 16 pp, Standard Pressed Steel Co
375—Hi-Temp Fasteners, 14 pp, Mercury Air Parts Co, Inc

MOTORS, ENGINES AND CONTROLS
356—Shaft Position Encoder, 4 pp, AR & T Electronics Inc
366—Motor-pump Units, 4 pp, Robbins & Myers Inc

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353—Potentiometers, 5 pp, Accuracy Inc
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358—Miniaturized Pressure Potentiometers, 4 pp, Trans-Sonics Inc
359—Cast Iron Footswitches, 4 pp, General Electric Co
362—Portable Electrical Testers, 8 pp, Daystrom Inc
363—Indicating Temperature Controls, 2 pp, United Electric Controls Co
364—Strain Reliefs, 4 pp, George Walker Co
365—Automation Accessories, 4 pp, Automatic Feeder Co
368—Miniature Rheostat, 2 pp, Hardwick, Hindle Inc
369—Photoelectric Tachometer, 2 pp, Simonds Worden White Co
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366—Motor-pump Units, 4 pp, Robbins & Myers Inc
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377—High-pressure Valves, 8 pp, Farrel-Birmingham Co Inc

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Company _____

Street _____ Home ☐ Plant ☐

City _____ Zone _____ State _____

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1	24	47	70	93	116	139	162	309	332	355	378	241
2	25	48	71	94	117	140	163	310	333	356	379	242
3	26	49	72	95	118	141	164	311	334	357	380	243
4	27	50	73	96	119	142	165	312	335	358	381	244
5	28	51	74	97	120	143	166	313	336	359	382	245
6	29	52	75	98	121	144	167	314	337	360	383	246
7	30	53	76	99	122	145	168	315	338	361	384	247
8	31	54	77	100	123	146	169	316	339	362	385	
9	32	55	78	101	124	147	170	317	340	363	386	
10	33	56	79	102	125	148	171	318	341	364	387	
11	34	57	80	103	126	149	172	319	342	365	388	
12	35	58	81	104	127	150	173	320	343	366	389	
13	36	59	82	105	128	151	174	321	344	367	390	
14	37	60	83	106	129	152	175	322	345	368	391	
15	38	61	84	107	130	153	300	323	346	369	392	
16	39	62	85	108	131	154	301	324	347	370	393	
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10	33	56	79	102	125	148	171	318	341	364	387	
11	34	57	80	103	126	149	172	319	342	365	388	
12	35	58	81	104	127	150	173	320	343	366	389	
13	36	59	82	105	128	151	174	321	344	367	390	
14	37	60	83	106	129	152	175	322	345	368	391	
15	38	61	84	107	130	153	300	323	346	369	392	
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Metal
B
Bearings
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Miniature
Needle
Roller
Sleeve
Belts, V
Bi-Metal
Blowers
Books
Brazing
Alloys
Bushings
C
Cameras & Accessories
Casters
Castings
Ceramics
Chains
Conveyor
Roller
Clamps
Clutches
Electrical
Coatings
Computers
Connectors
Electrical
Hose
Tube
Contactors
Controllers
Control Panels & Switchbo
Controls
Hydraulic
Mechanical
Cords
Couplings
Hydraulic
Mechanical
Cylinders
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Die Castings
Digital Displays
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F
Fastening Methods
Felt
Fibre
Fibre Glass
Filters
Air
Fittings, Hose, Pipe & Tub
Flexible Shafts
Floats
Furniture, Engrg. Dept.
G
Gaskets
Gears
Glass
H
Heating Units
Instruments
I
Mechanical
J
Jacks
L
Locks
Lubricating Equipment
M
Metal Forming
Moldings
Powdered Metal (see Pow
Rubber (see Rubber Part
Motor Starters
Motors, A-C
Fractional
4th
Integral
Sub-Fractional
Motors, D-C
Fractional
4th Cove
Integral
Sub-Fractional
P
Packings
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Photographic Equipment, Fi
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Powdered Metal Parts
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Pumps
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Relays
Reproduction Supplies
Resins
Retaining Rings
Rubber
Rubber Parts

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25th FLOOR

NATIONAL OIL SEAL LOGBOOK

Ask yourself these questions when specifying oil seals

SHAFT RPM, FPM, RUNOUT, ENDPLAY	Is seal rated at or above my anticipated operating extremes? ☐ YES ☐ NO
TEMPERATURE, LUBRICANT TYPES	Will heat or special-purpose lubricants attack my sealing lip compounds? ☐ YES ☐ NO
PRESENCE OF DIRT OR OTHER FOREIGN MATERIAL	Point often overlooked. If present, should I specify dual-lip sealing member? ☐ YES ☐ NO
COST RELATED TO SEAL DESIGN	Will a simpler, less expensive seal do as good a job as a more sophisticated unit? ☐ YES ☐ NO
NEW SEAL DESIGNS AND MATERIALS ON MARKET	Are there new high temperature, high speed compounds I should examine before specifying? ☐ YES ☐ NO
SPECIAL DESIGNS FOR SPECIAL PROBLEMS	Not all sealing jobs can be met with stock seals. Do I need a special factory design? ☐ YES ☐ NO
DELIVERY, REPUTATION FOR QUALITY	Is my resource noted for on-time delivery, uniform quality, and good follow-up service? ☐ YES ☐ NO

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NATIONAL SEAL
Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
Plants: Redwood City and Downey, California
Van Wert, Ohio

4869

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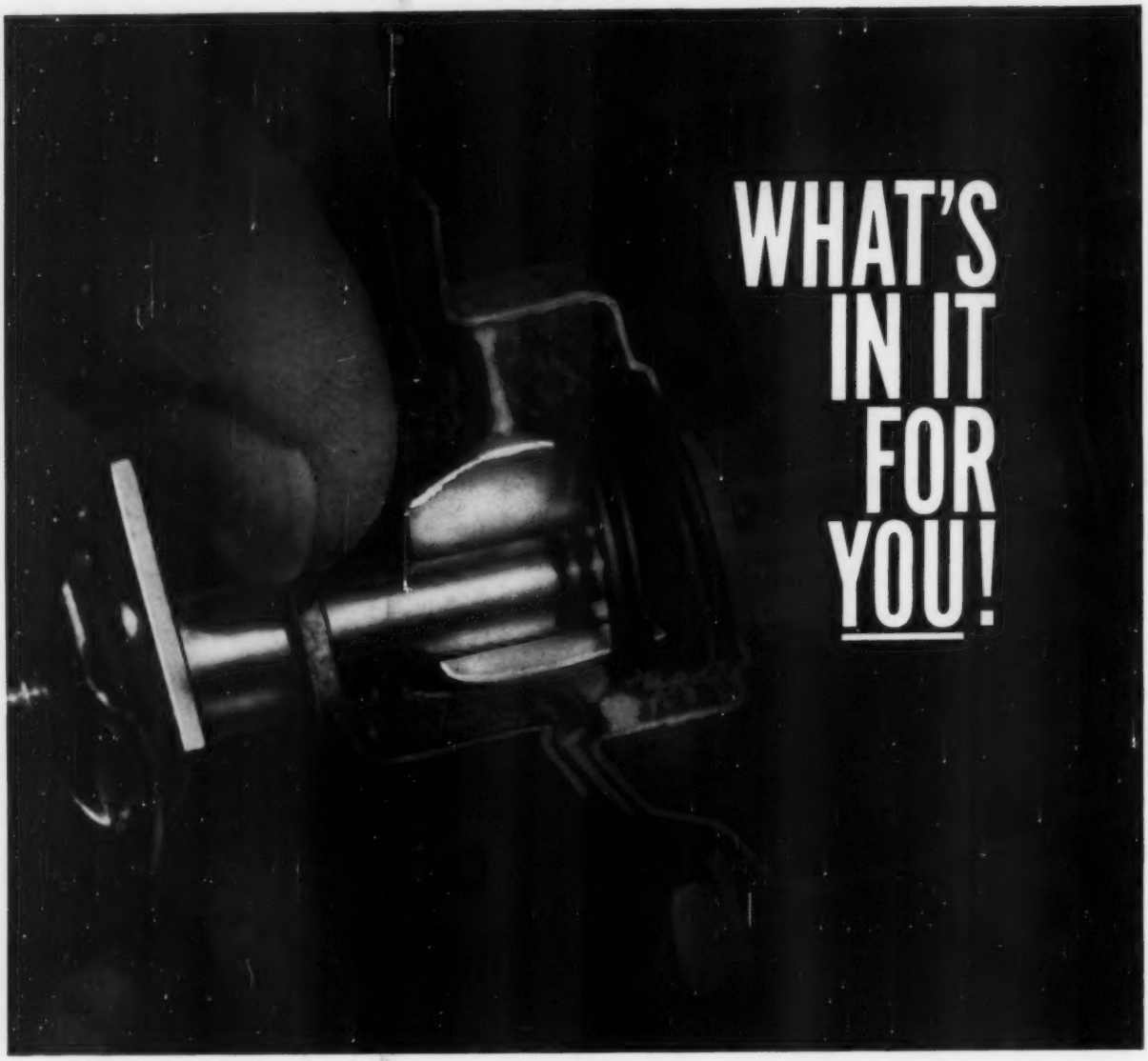

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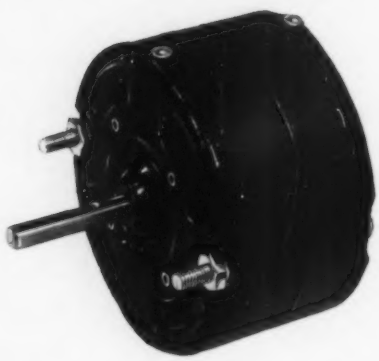
The bronze bearing in Emerson Electric Motors has thousands of tiny cells that cause the bearing to act as a metal sponge and feed the shaft journal a controlled flow of lubricant. In cooling, it draws off excess oil to give free starting at low temperatures. Self-Alignment minimizes friction and greatly increases motor life when you install *Emerson Electric Motors* in your appliances and equipment. Emerson Electric Motors are custom-engineered to meet your specific needs. Call us *today* . . . you'll like our way of doing business!



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